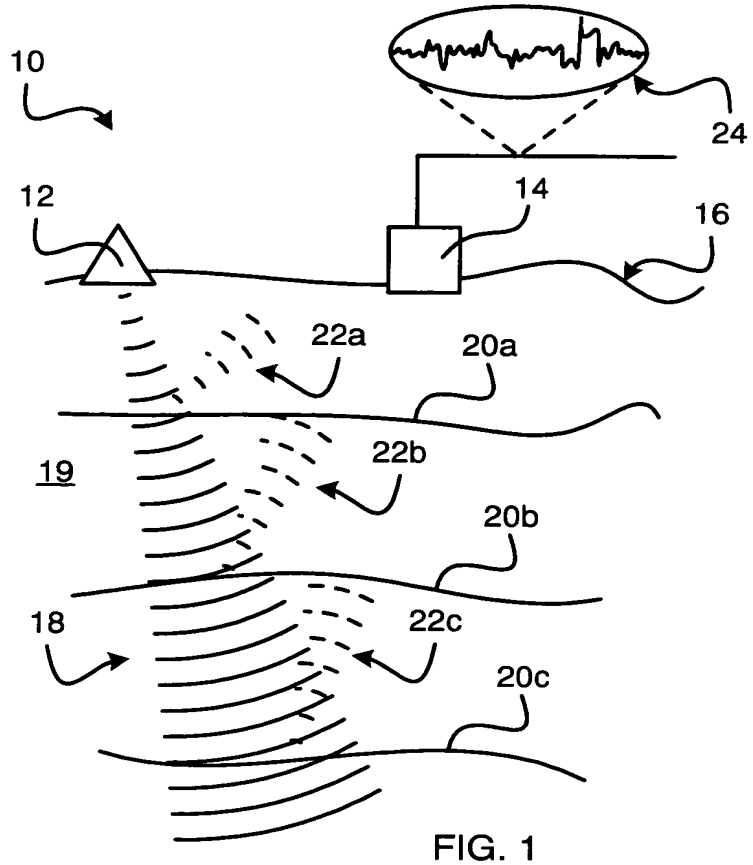


FIG. 1

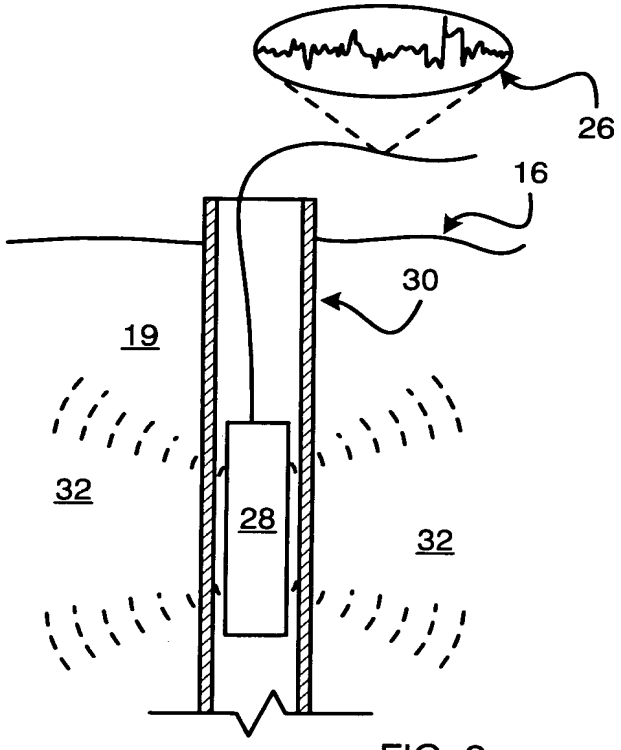


FIG. 2

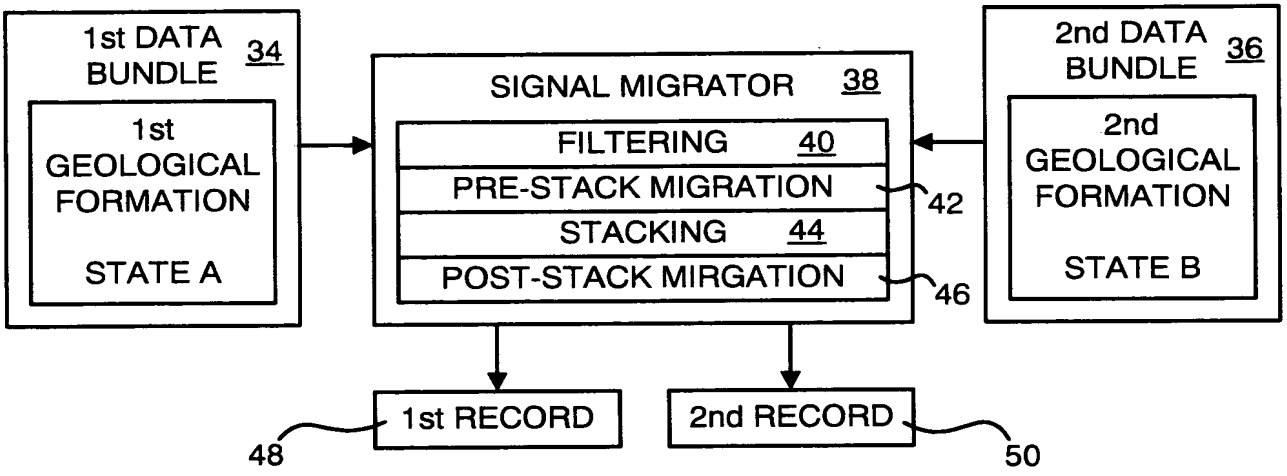

1st DATA BUNDLE 34
1st GEOLOGICAL FORMATION
STATE A
SIGNAL MIGRATOR 38
FILTERING 40
PRE-STACK MIGRATION
STACKING 44
POST-STACK MIRGATION
42
46
2nd DATA BUNDLE 36
2nd GEOLOGICAL FORMATION
STATE B
1st RECORD
2nd RECORD
48
50

FIG. 3

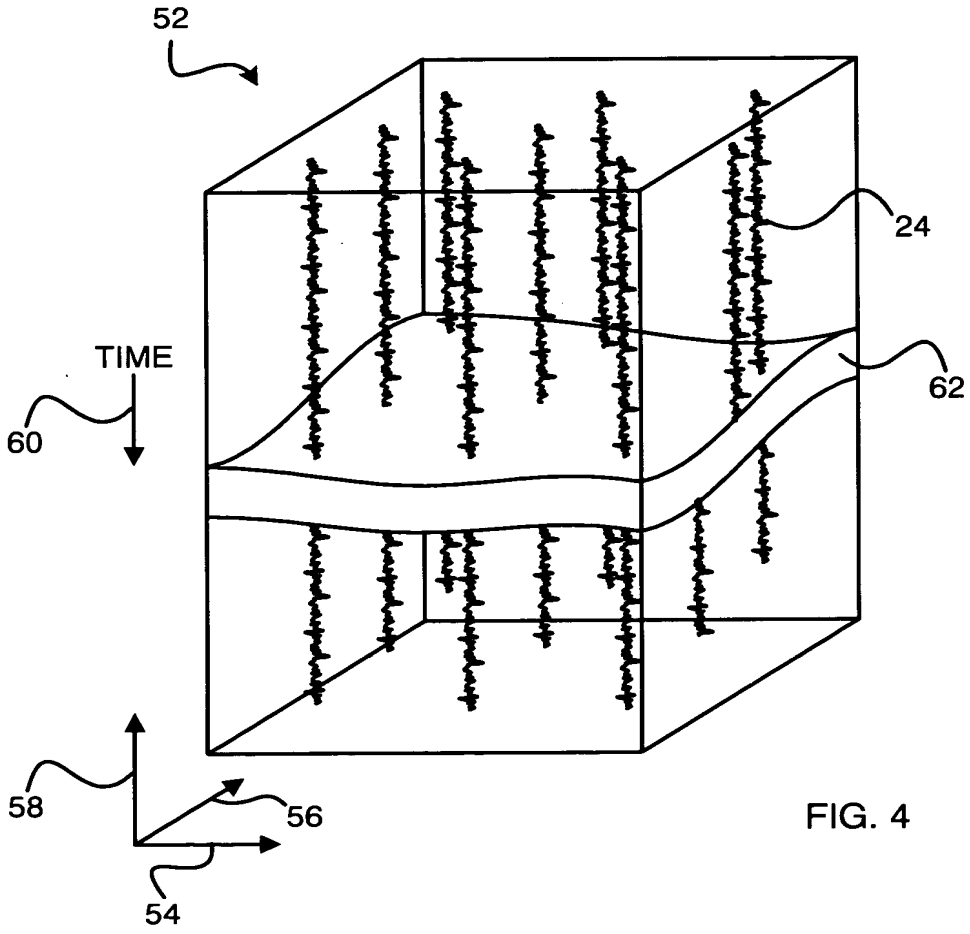

52
24
TIME
60
62
58
56
54

FIG. 4

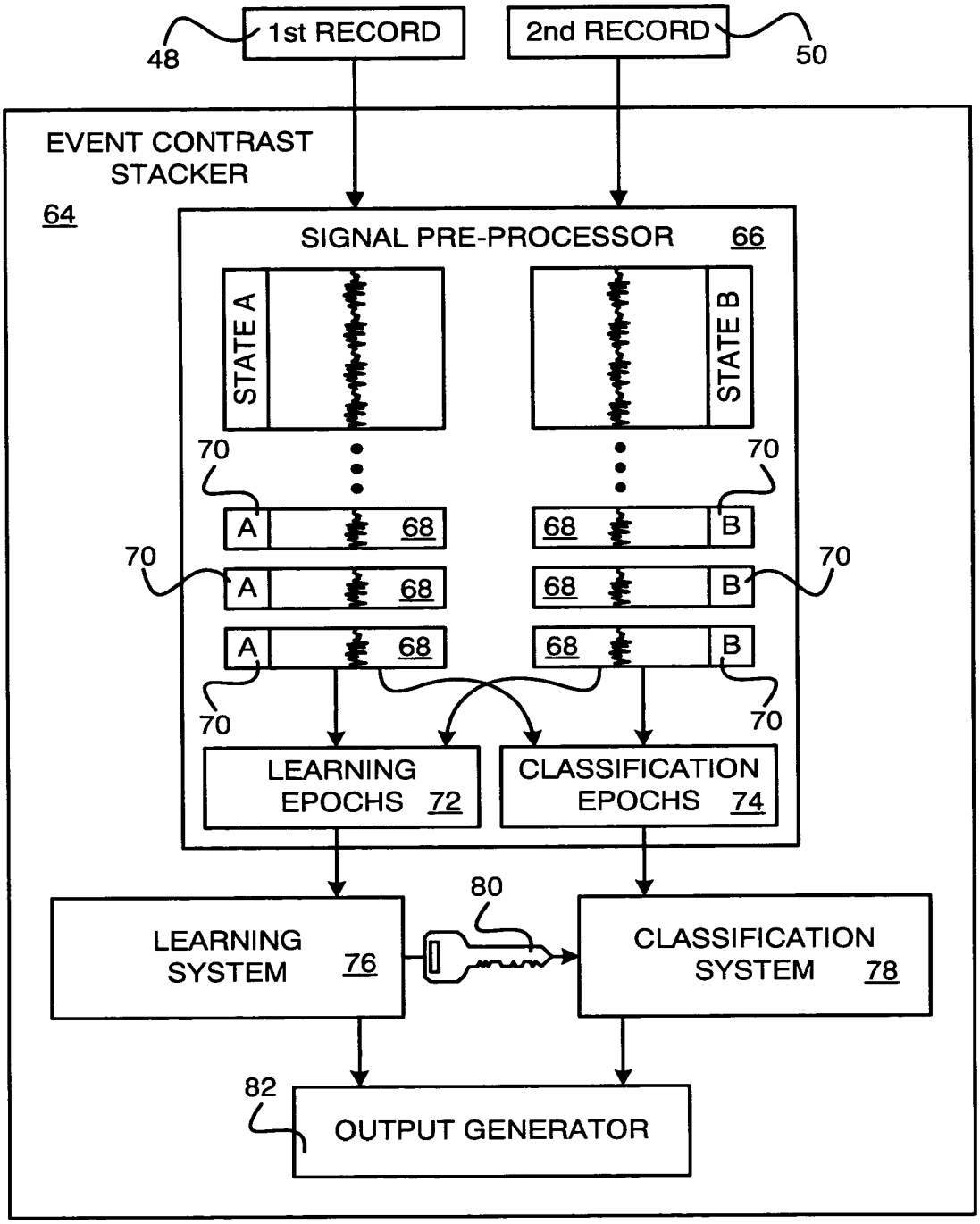

1st RECORD
2nd RECORD
48
50
EVENT CONTRAST STACKER
64
SIGNAL PRE-PROCESSOR 66
STATE A
STATE B
70
A
68
B
LEARNING EPOCHS 72
CLASSIFICATION EPOCHS 74
80
LEARNING SYSTEM 76
CLASSIFICATION SYSTEM 78
82
OUTPUT GENERATOR

FIG. 5

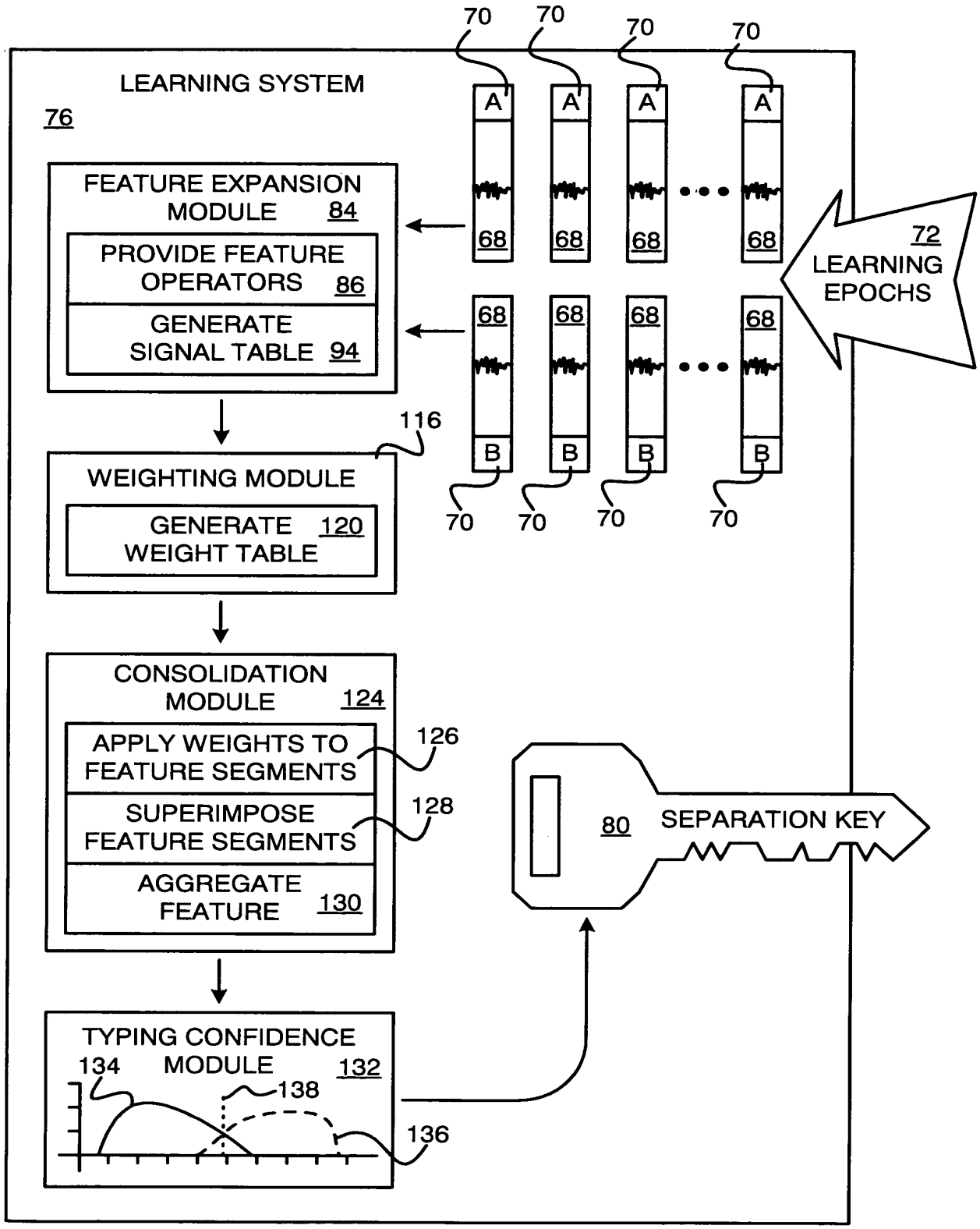

LEARNING SYSTEM
76
FEATURE EXPANSION MODULE 84
PROVIDE FEATURE OPERATORS 86
GENERATE SIGNAL TABLE 94
WEIGHTING MODULE
GENERATE WEIGHT TABLE 120
116
CONSOLIDATION MODULE 124
APPLY WEIGHTS TO FEATURE SEGMENTS
126
SUPERIMPOSE FEATURE SEGMENTS
128
AGGREGATE FEATURE 130
TYPING CONFIDENCE MODULE 132
134
138
136
70
A
B
68
72 LEARNING EPOCHS
80 SEPARATION KEY

FIG. 6

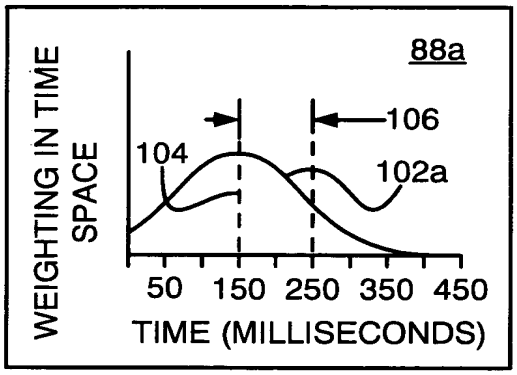


FIG. 7

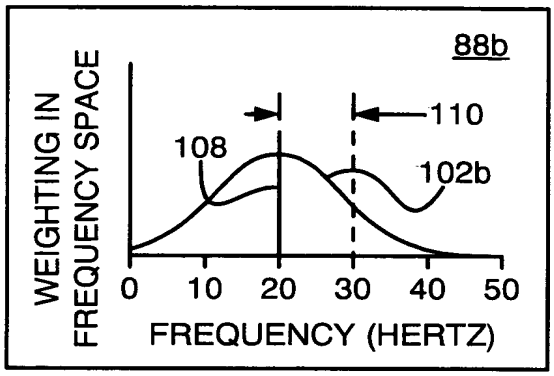


FIG. 8

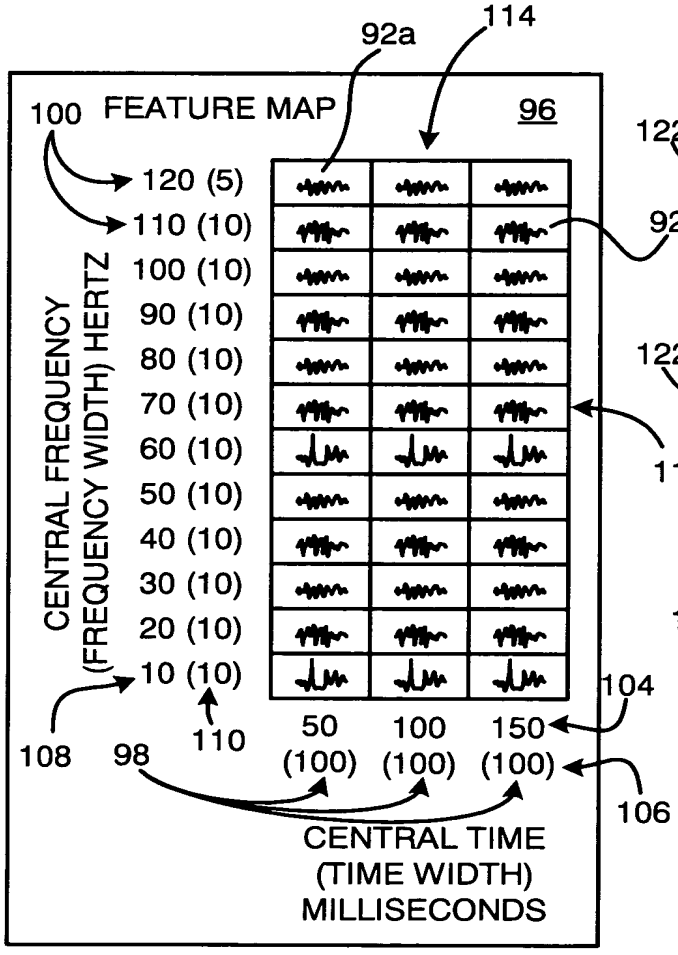


FIG. 9

122a

WEIGHTING TABLE 118

0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00
-0.04	-0.04	0.04
0.03	0.03	0.05
0.00	-0.05	0.04
0.03	-0.06	0.11
0.01	0.01	-0.09
-0.14	0.19	-0.03
0.29	-0.47	0.18
-0.33	0.55	-0.24
0.15	-0.25	0.12

122

112

FIG. 10

114

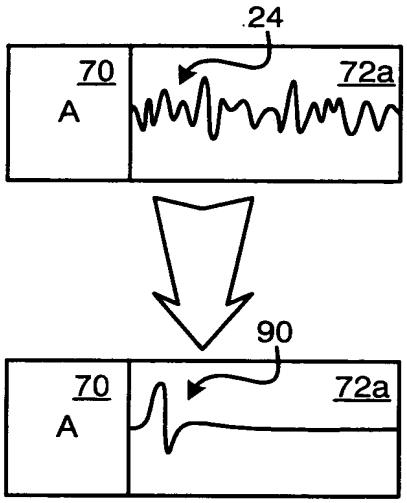


FIG. 11

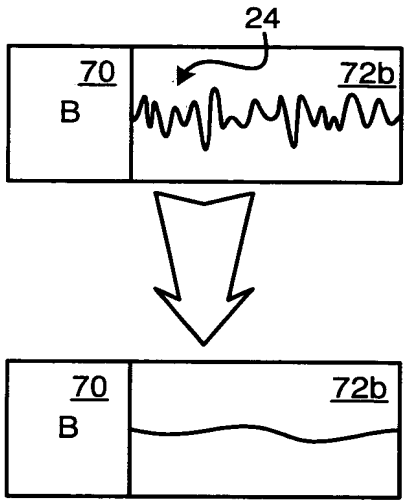


FIG. 12

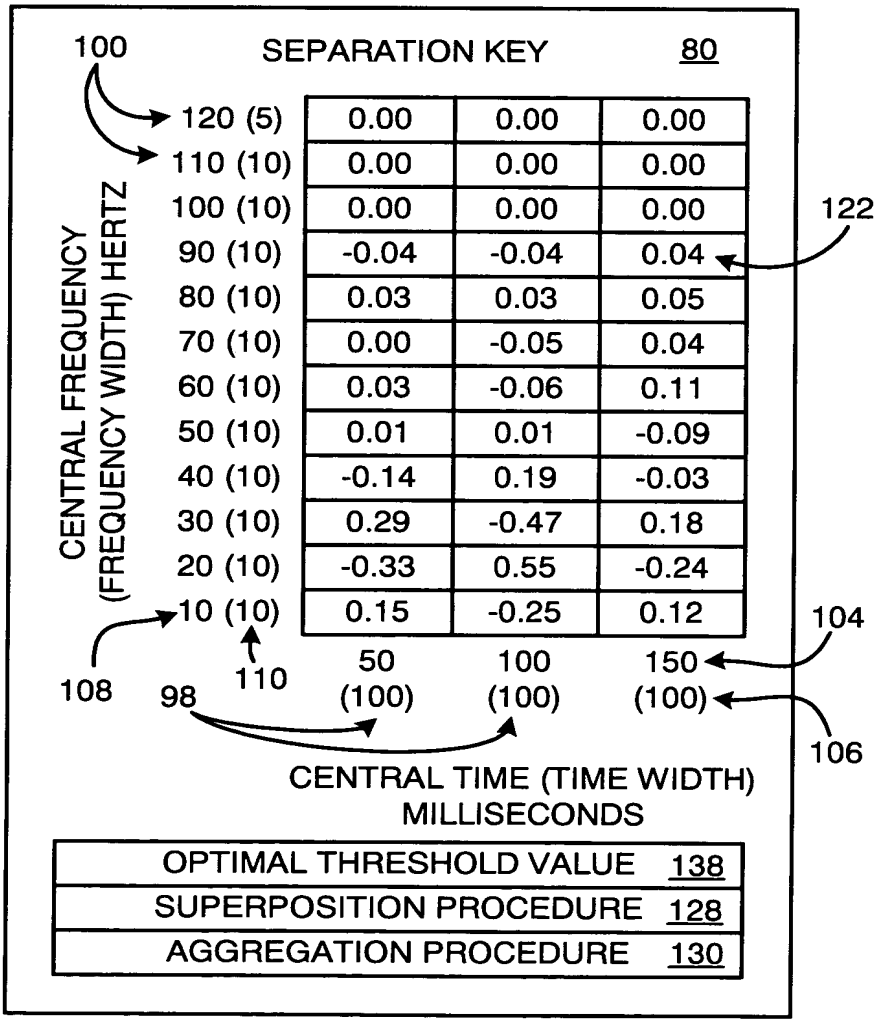


FIG. 13

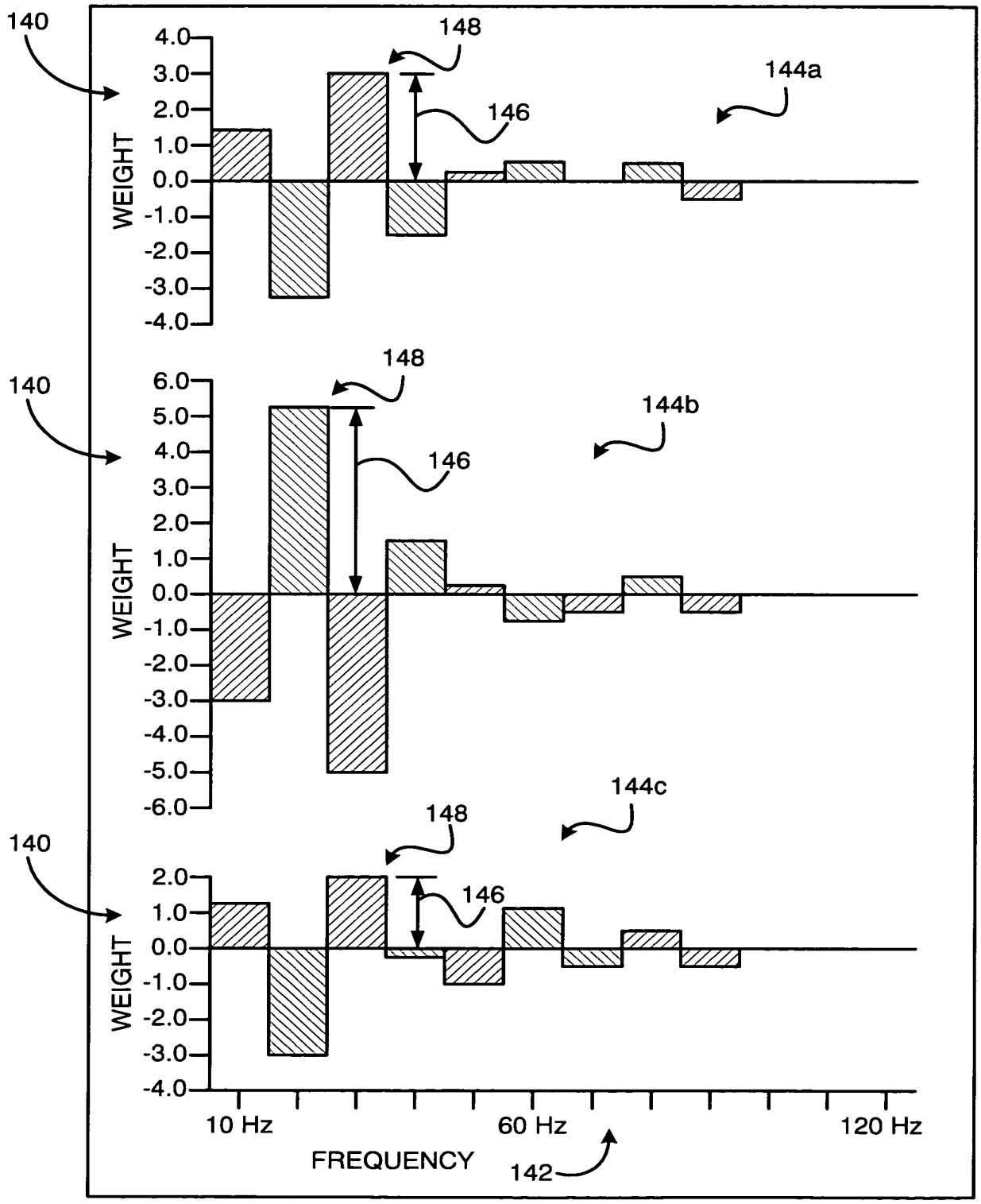

140
148
144a
146
WEIGHT
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
140
148
144b
146
WEIGHT
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
140
144c
148
146
WEIGHT
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
10 Hz
60 Hz
120 Hz
FREQUENCY
142

FIG. 14

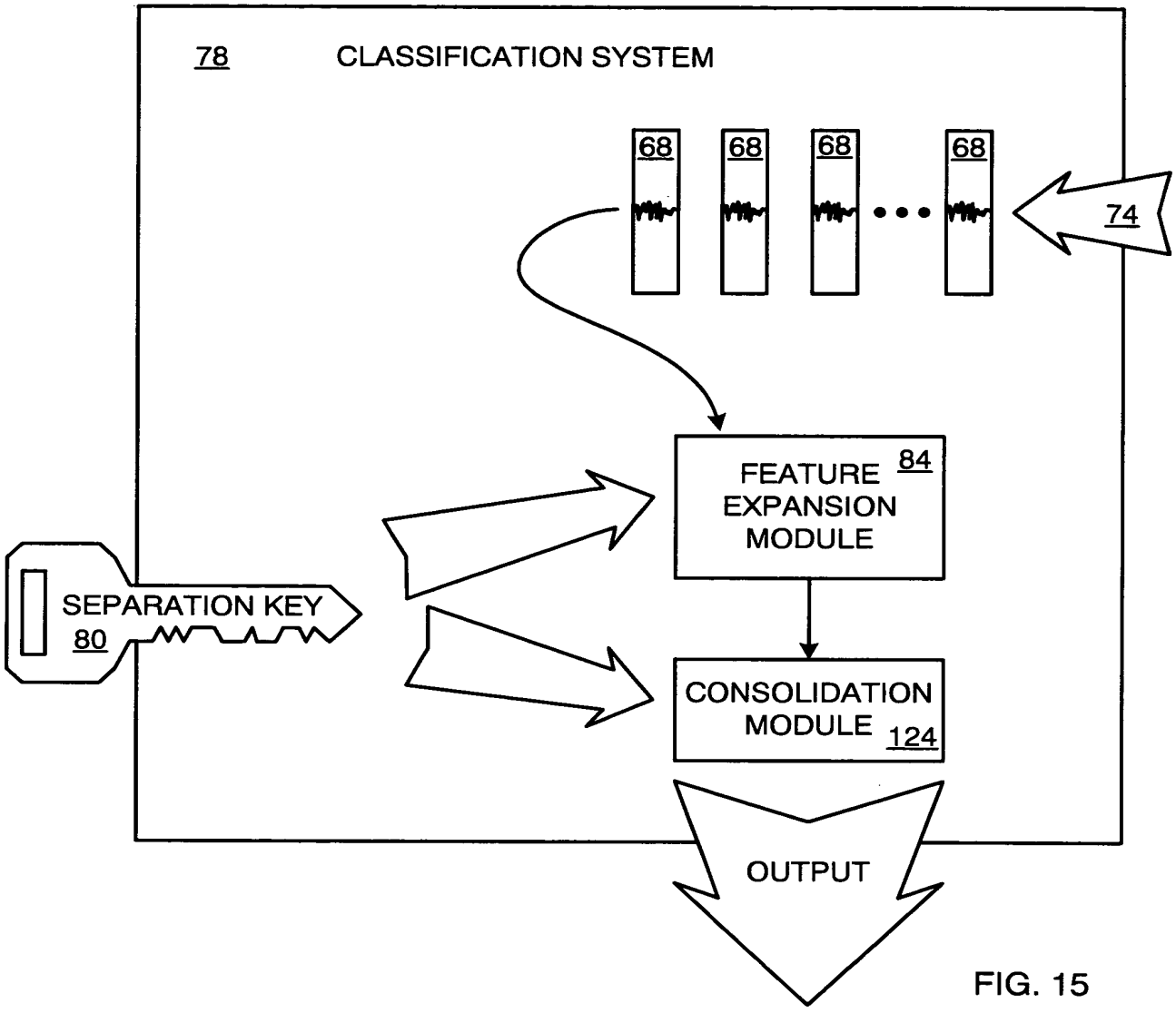

78
CLASSIFICATION SYSTEM
68
68
68
68
74
FEATURE EXPANSION MODULE
84
SEPARATION KEY
80
CONSOLIDATION MODULE
124
OUTPUT

FIG. 15

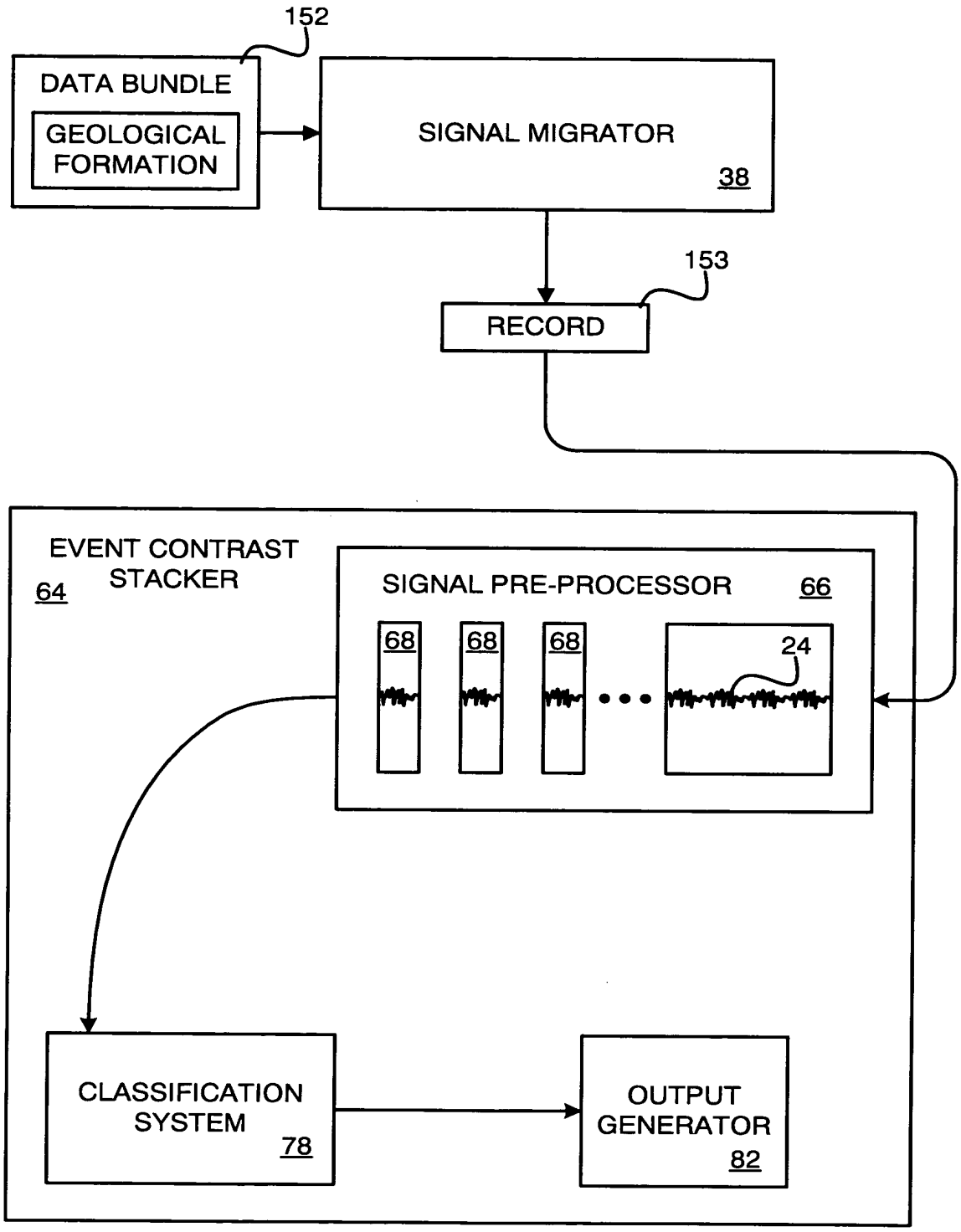

152
DATA BUNDLE
GEOLOGICAL FORMATION
SIGNAL MIGRATOR
38
153
RECORD
EVENT CONTRAST STACKER
64
SIGNAL PRE-PROCESSOR
66
68
68
68
24
CLASSIFICATION SYSTEM
78
OUTPUT GENERATOR
82

FIG. 16

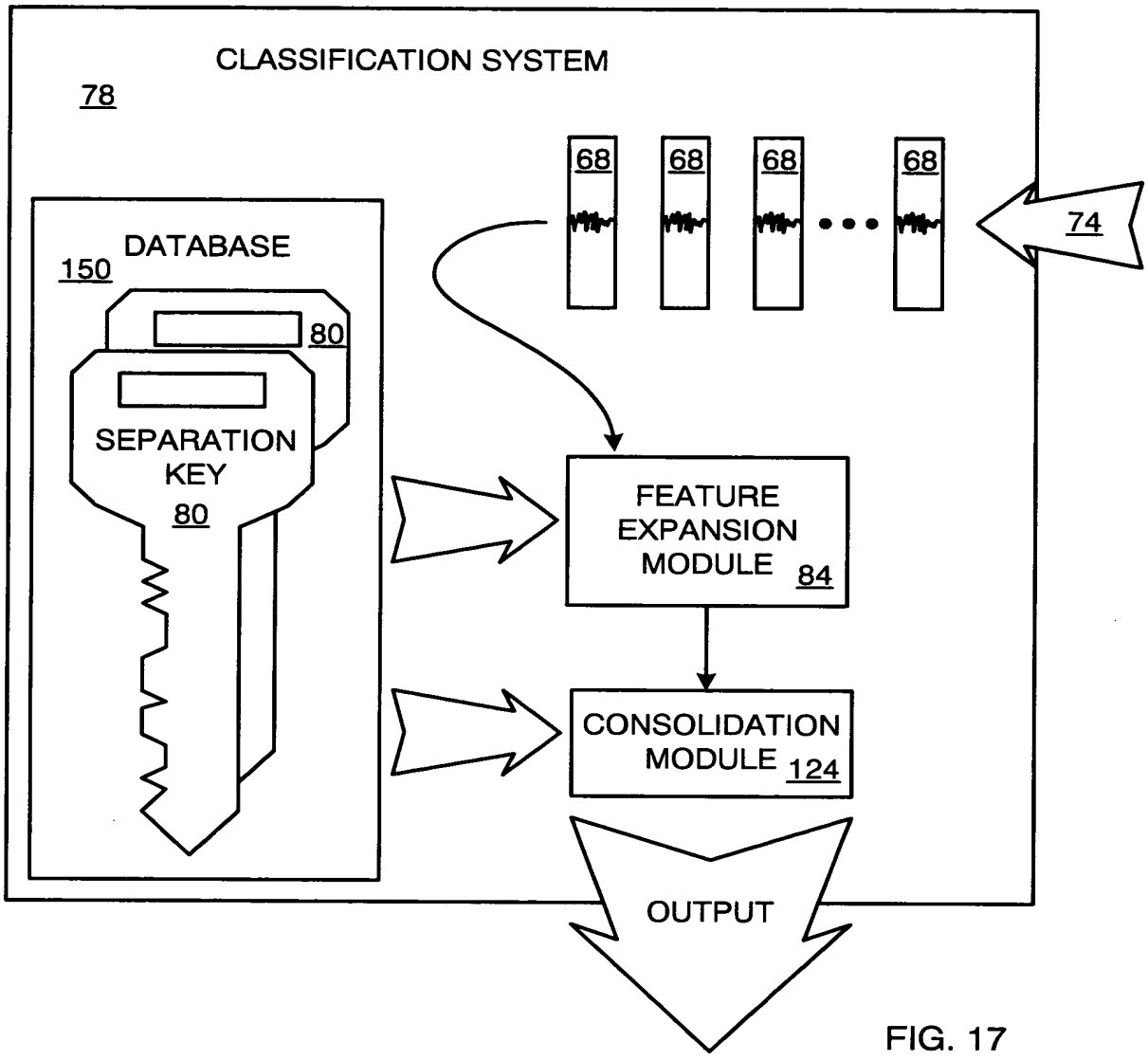

CLASSIFICATION SYSTEM
78
68
68
68
68
74
DATABASE
150
80
SEPARATION KEY
80
FEATURE EXPANSION MODULE 84
CONSOLIDATION MODULE 124
OUTPUT

FIG. 17

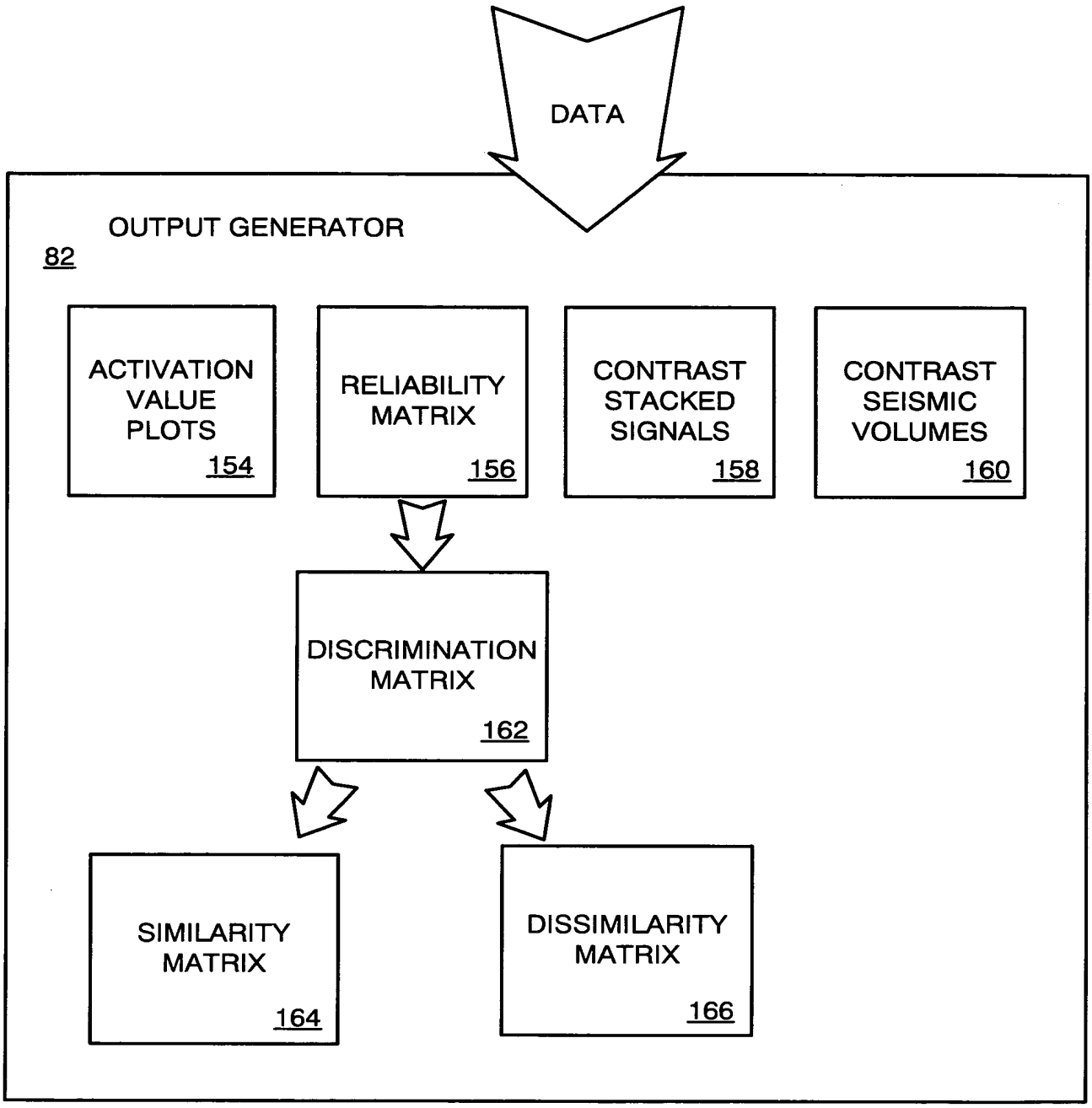

DATA
OUTPUT GENERATOR
82
ACTIVATION VALUE PLOTS
154
RELIABILITY MATRIX
156
CONTRAST STACKED SIGNALS
158
CONTRAST SEISMIC VOLUMES
160
DISCRIMINATION MATRIX
162
SIMILARITY MATRIX
164
DISSIMILARITY MATRIX
166

FIG. 18

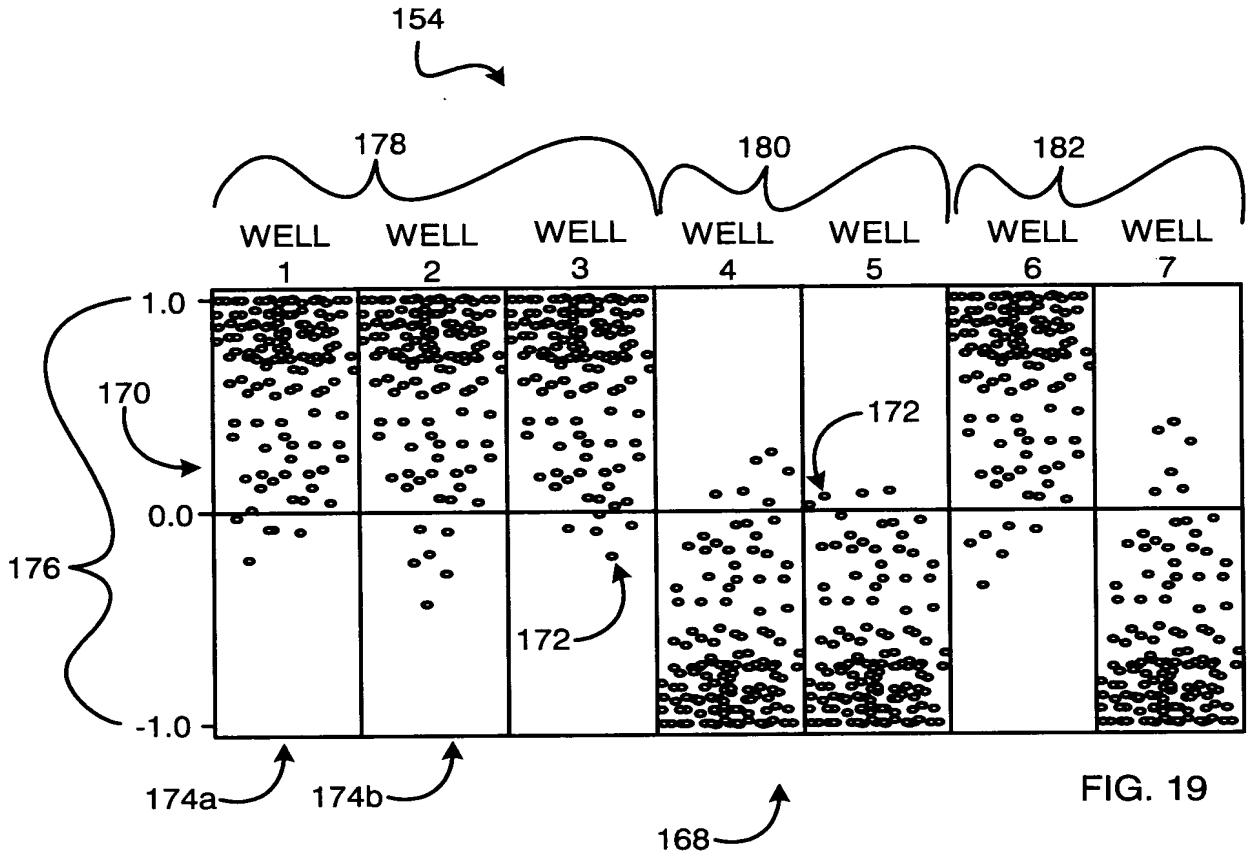

154
178
180
182
WELL 1
WELL 2
WELL 3
WELL 4
WELL 5
WELL 6
WELL 7
1.0
0.0
-1.0
170
172
172
176
174a
174b
168

FIG. 19

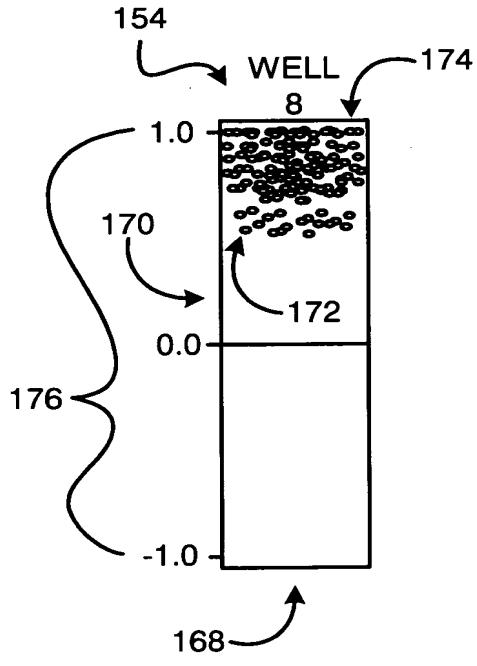

154
WELL 8
174
1.0
170
172
0.0
176
-1.0
168

FIG. 20

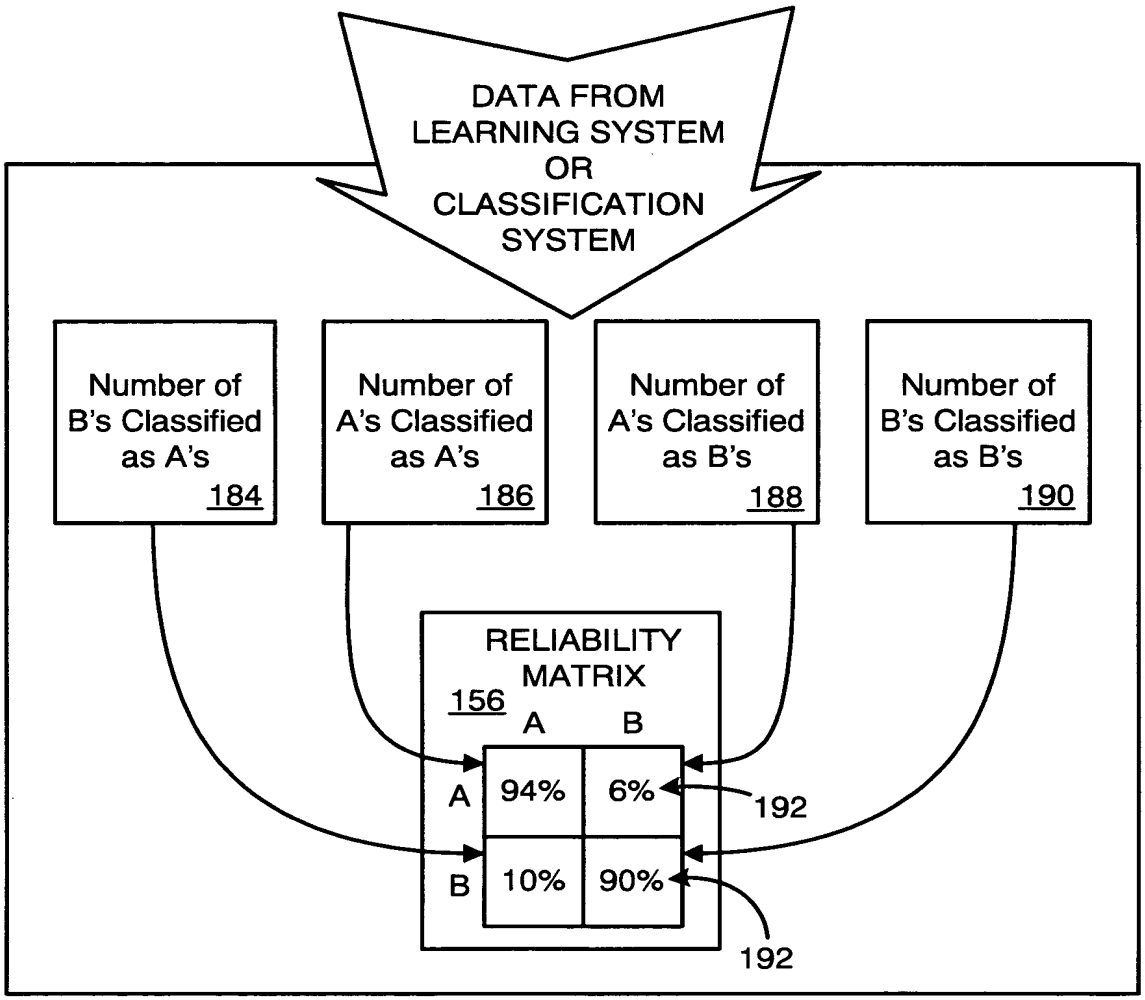

DATA FROM
LEARNING SYSTEM
OR
CLASSIFICATION
SYSTEM
Number of
B's Classified
as A's
184
Number of
A's Classified
as A's
186
Number of
A's Classified
as B's
188
Number of
B's Classified
as B's
190
RELIABILITY
MATRIX
156
A
B
A
94%
6%
192
B
10%
90%
192

FIG. 21

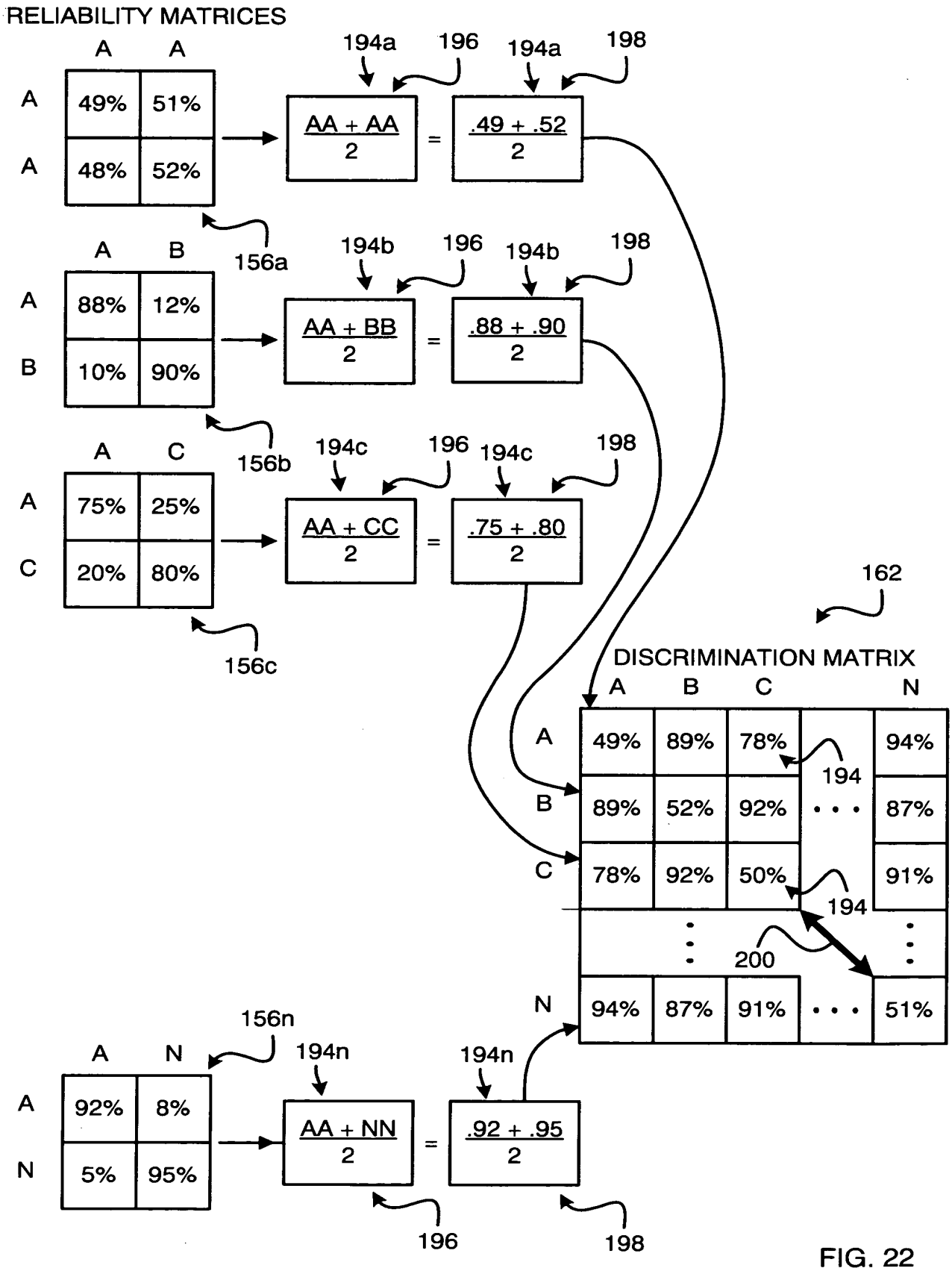

RELIABILITY MATRICES
A A
A 49% 51%
A 48% 52%
156a
194a 196 194a 198
AA + AA / 2 = .49 + .52 / 2
A B
A 88% 12%
B 10% 90%
156b
194b 196 194b 198
AA + BB / 2 = .88 + .90 / 2
A C
A 75% 25%
C 20% 80%
156c
194c 196 194c 198
AA + CC / 2 = .75 + .80 / 2
162
DISCRIMINATION MATRIX
A B C N
A 49% 89% 78% 94%
B 89% 52% 92% 87%
C 78% 92% 50% 91%
N 94% 87% 91% 51%
194
194
200
A N
A 92% 8%
N 5% 95%
156n
194n 194n
AA + NN / 2 = .92 + .95 / 2
196 198

FIG. 22

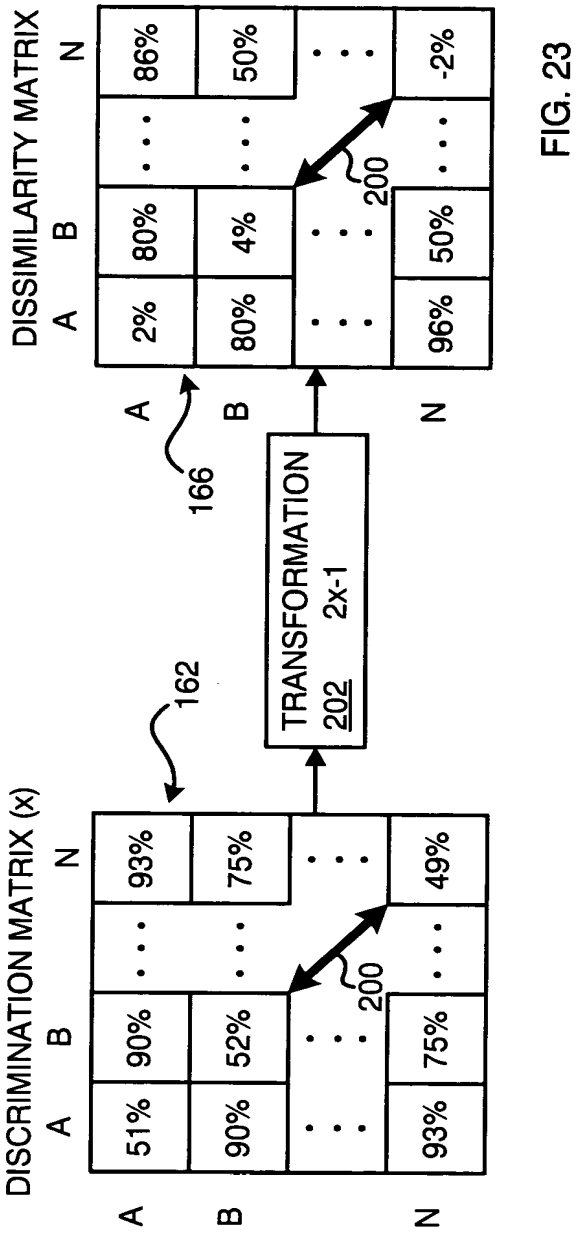

DISCRIMINATION MATRIX (x)
A B N
A 51% 90% ... 93%
B 90% 52% ... 75%
... ...
N 93% 75% ... 49%
162
200
TRANSFORMATION
202 2x-1
166
DISSIMILARITY MATRIX
A B N
A 2% 80% ... 86%
B 80% 4% ... 50%
... ...
N 96% 50% ... -2%
200

FIG. 23

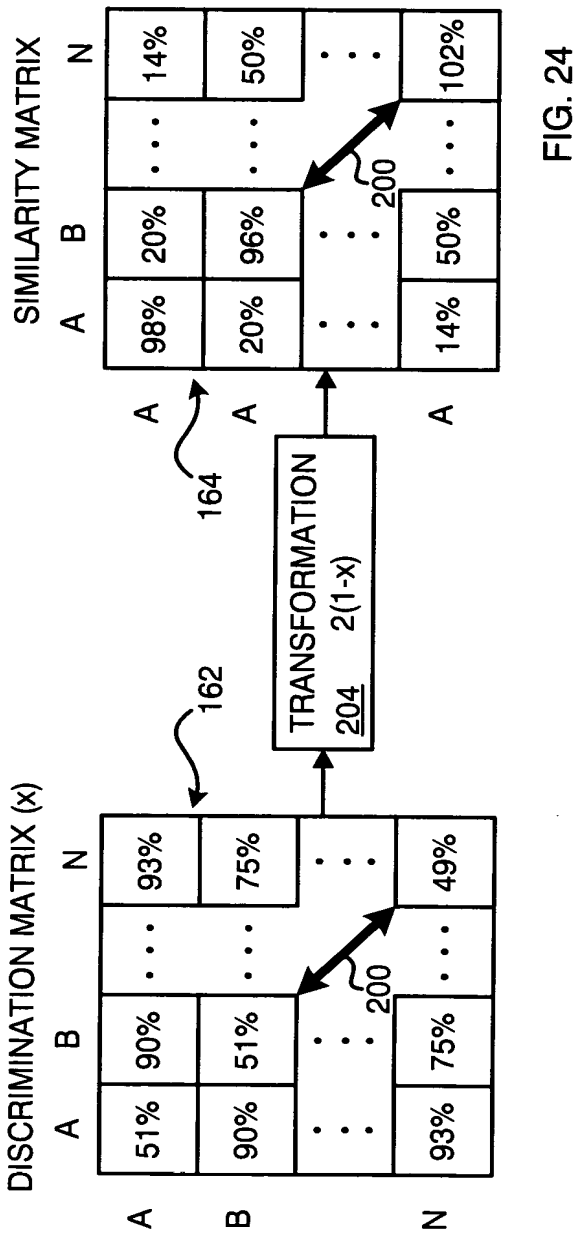

DISCRIMINATION MATRIX (x)
A B N
A 51% 90% ... 93%
B 90% 51% ... 75%
... ...
N 93% 75% ... 49%
162
200
TRANSFORMATION
204 2(1-x)
164
SIMILARITY MATRIX
A B N
A 98% 20% ... 14%
B 20% 96% ... 50%
... ...
N 14% 50% ... 102%
200

FIG. 24

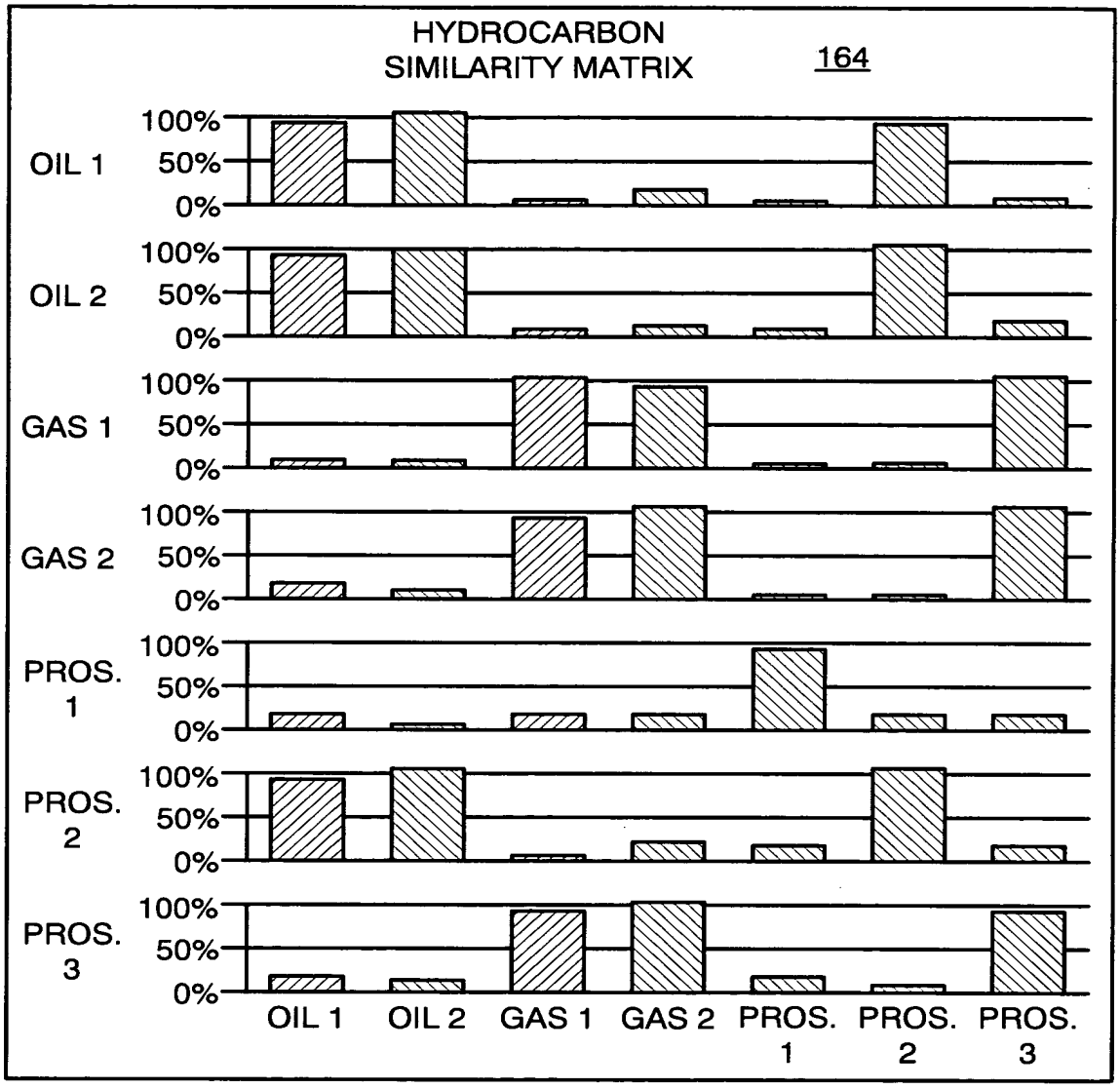
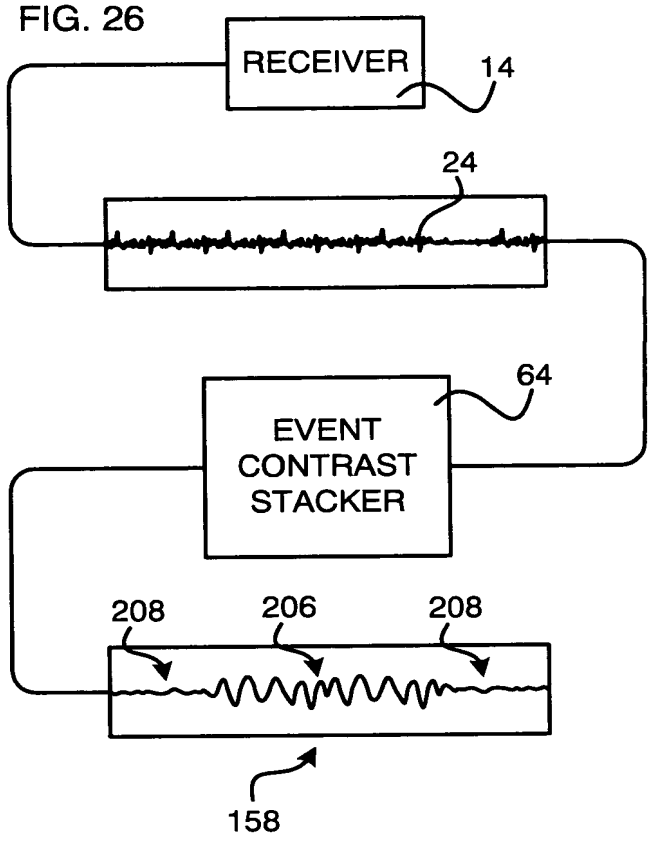

HYDROCARBON
SIMILARITY MATRIX
164
OIL 1
OIL 2
GAS 1
GAS 2
PROS. 1
PROS. 2
PROS. 3
100%
50%
0%
OIL 1
OIL 2
GAS 1
GAS 2
PROS. 1
PROS. 2
PROS. 3

FIG. 25

FIG. 26



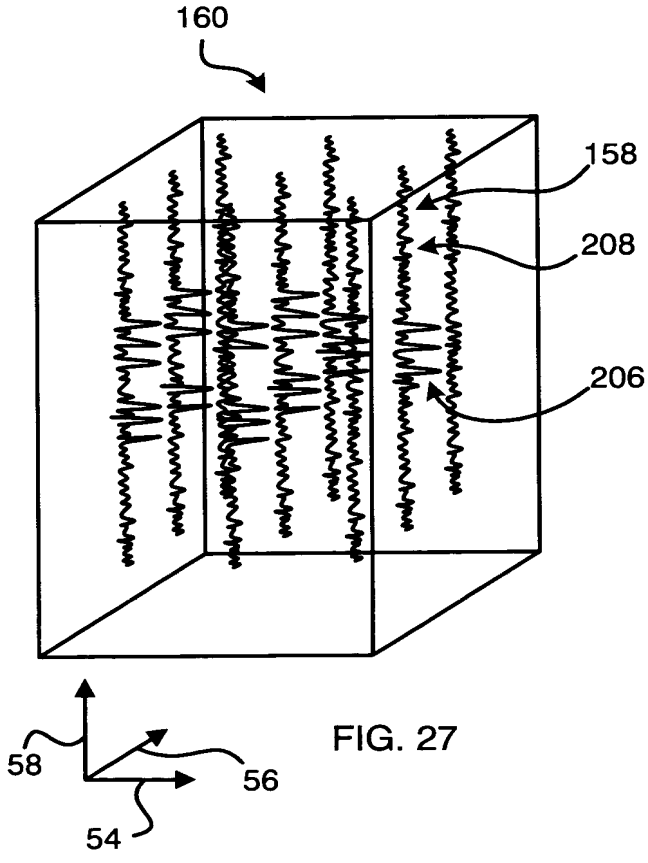


FIG. 27

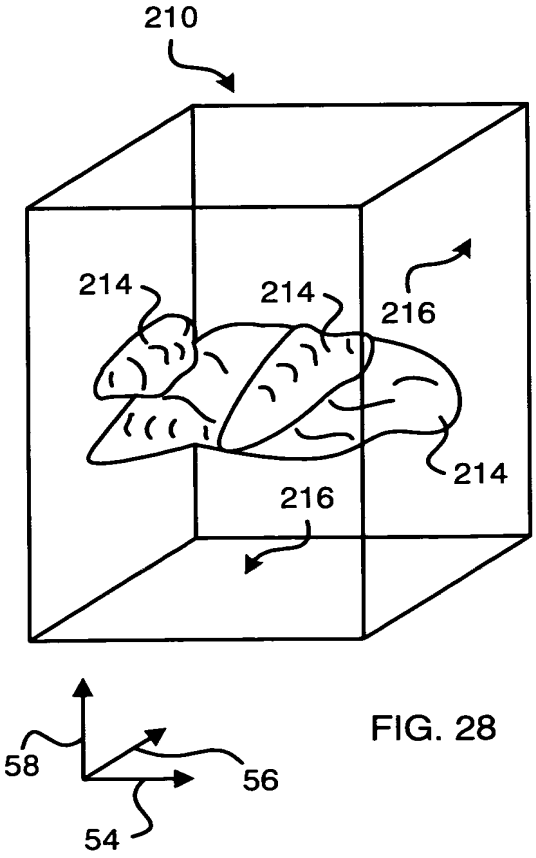


FIG. 28

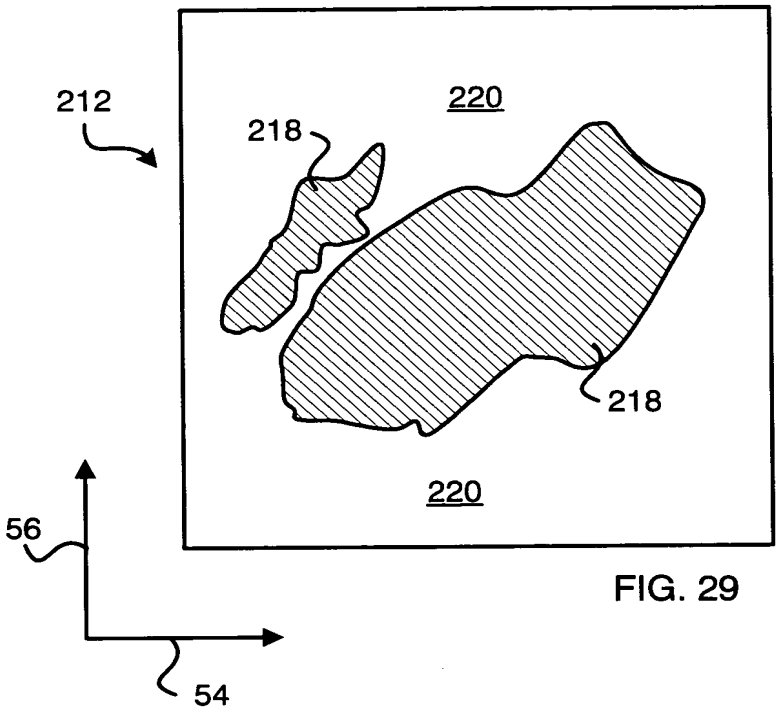


FIG. 29

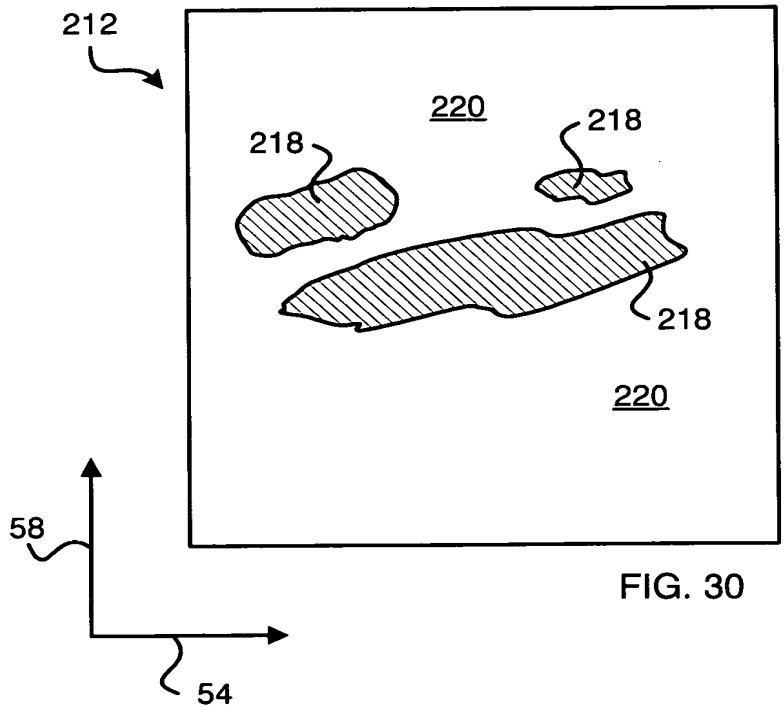
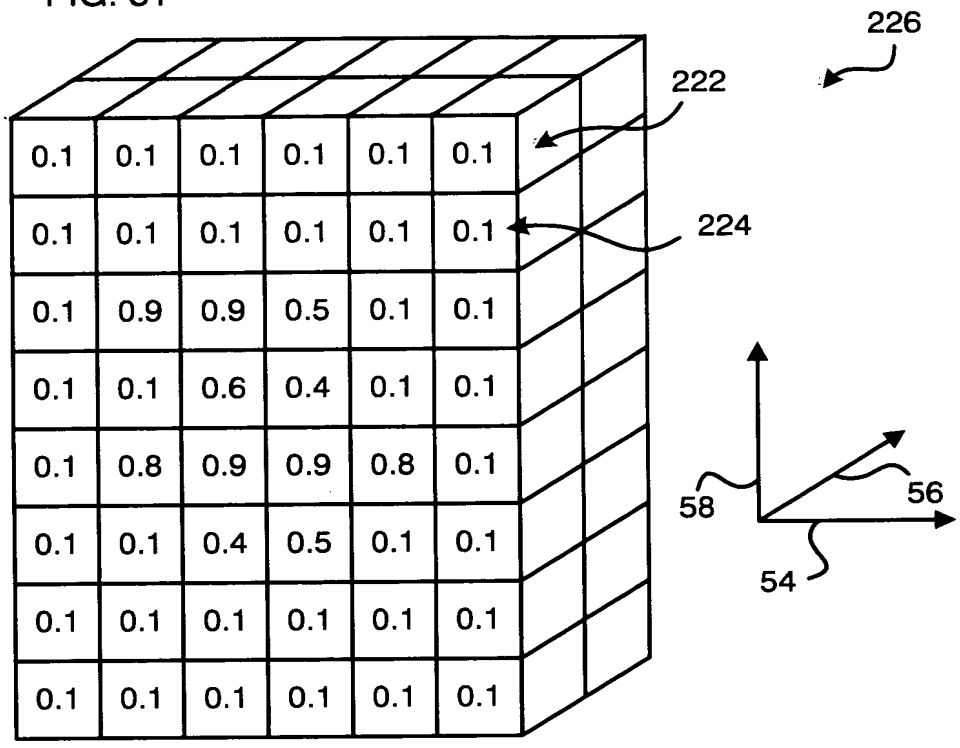


FIG. 30

FIG. 31


226
222
224
0.1 0.1 0.1 0.1 0.1 0.1
0.1 0.1 0.1 0.1 0.1 0.1
0.1 0.9 0.9 0.5 0.1 0.1
0.1 0.1 0.6 0.4 0.1 0.1
0.1 0.8 0.9 0.9 0.8 0.1
0.1 0.1 0.4 0.5 0.1 0.1
0.1 0.1 0.1 0.1 0.1 0.1
0.1 0.1 0.1 0.1 0.1 0.1
58
56
54

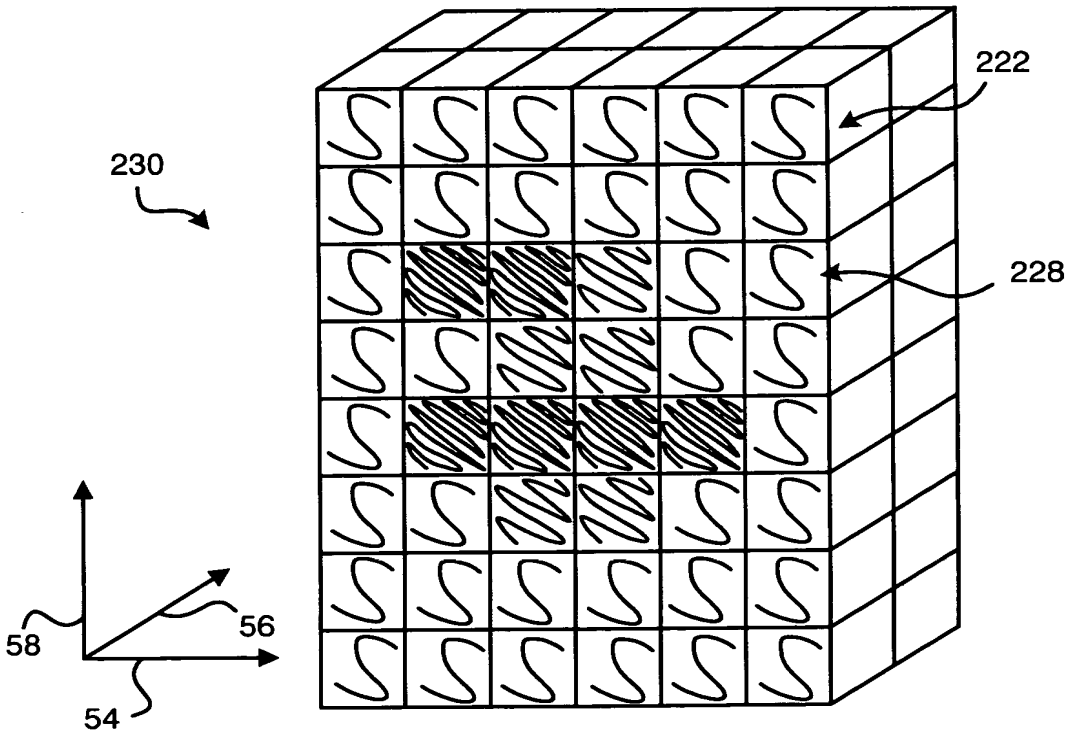

230
222
228
58
56
54

FIG. 32

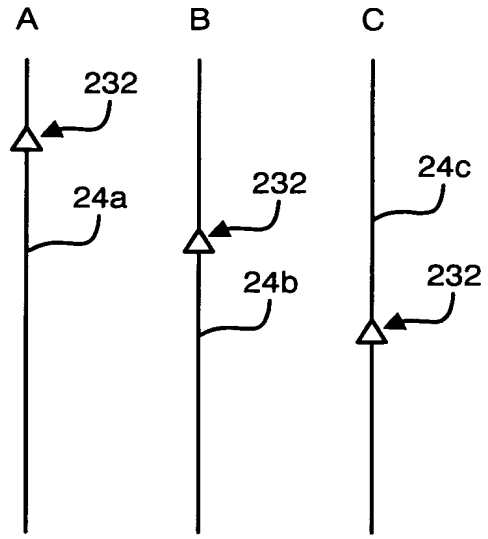


FIG. 33

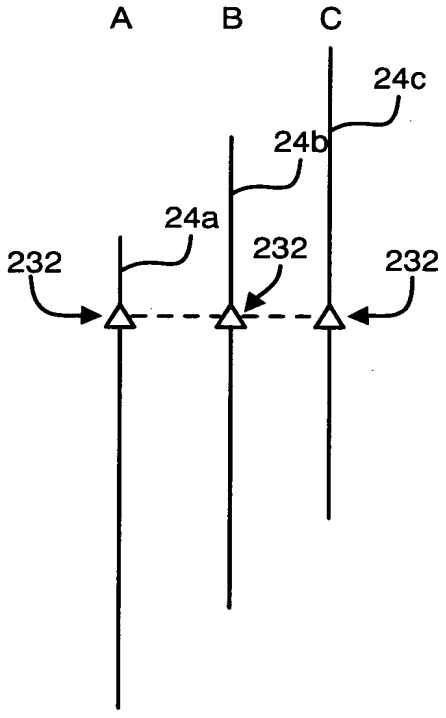


FIG. 34

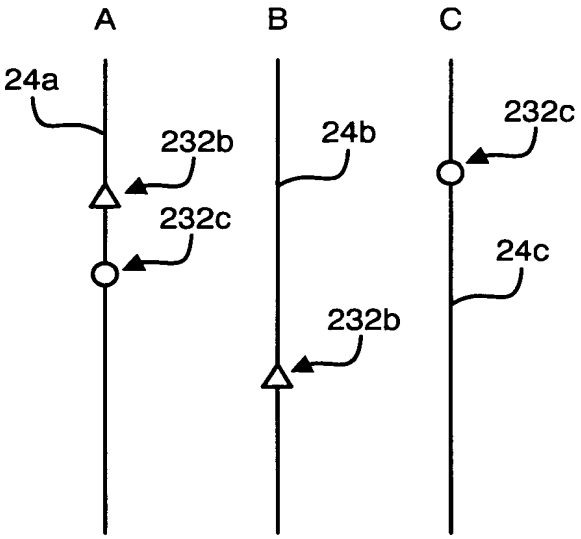

A
B
C
24a
232b
232c
24b
232b
232c
24c

FIG. 35

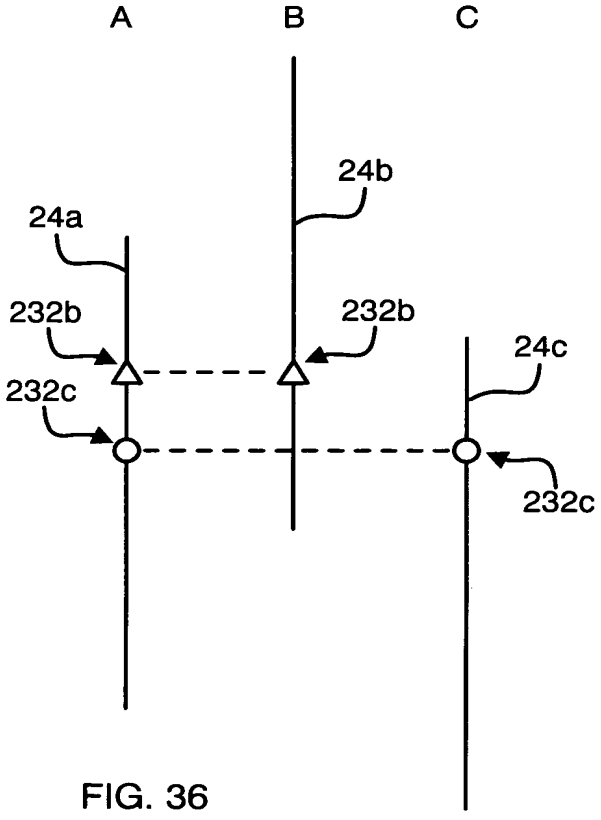
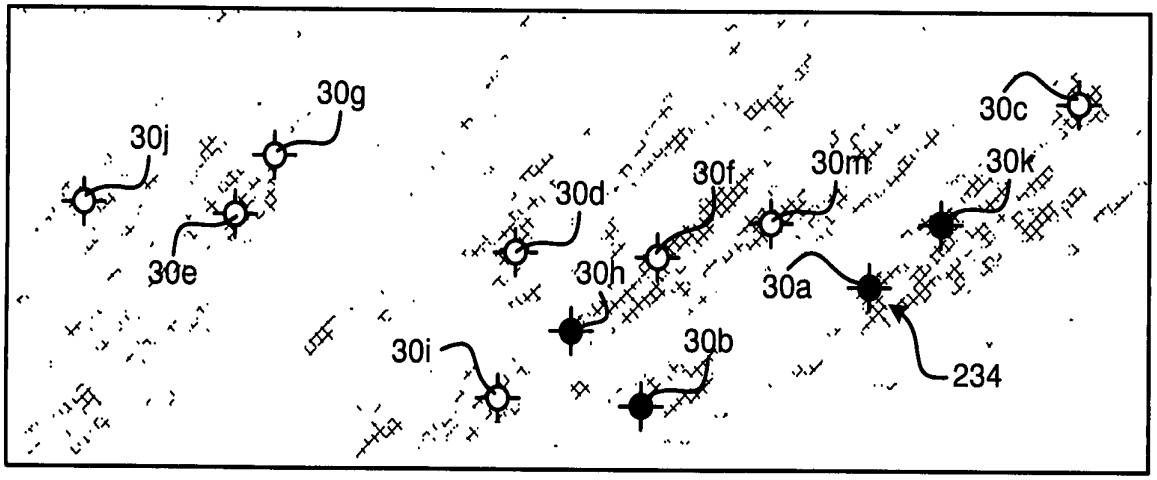

A
B
C
24b
24a
232b
232b
24c
232c
232c

FIG. 36

PRIOR ART SEISMIC VOLUME



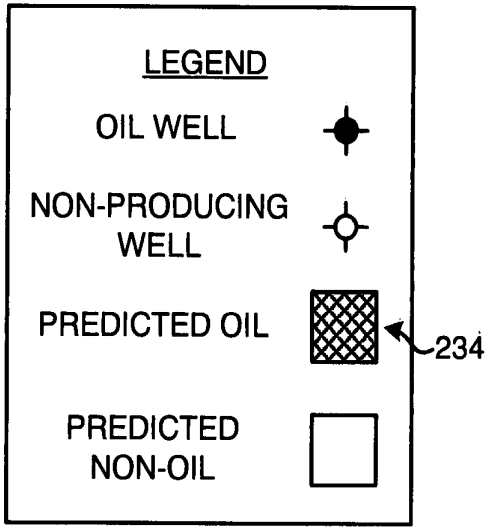
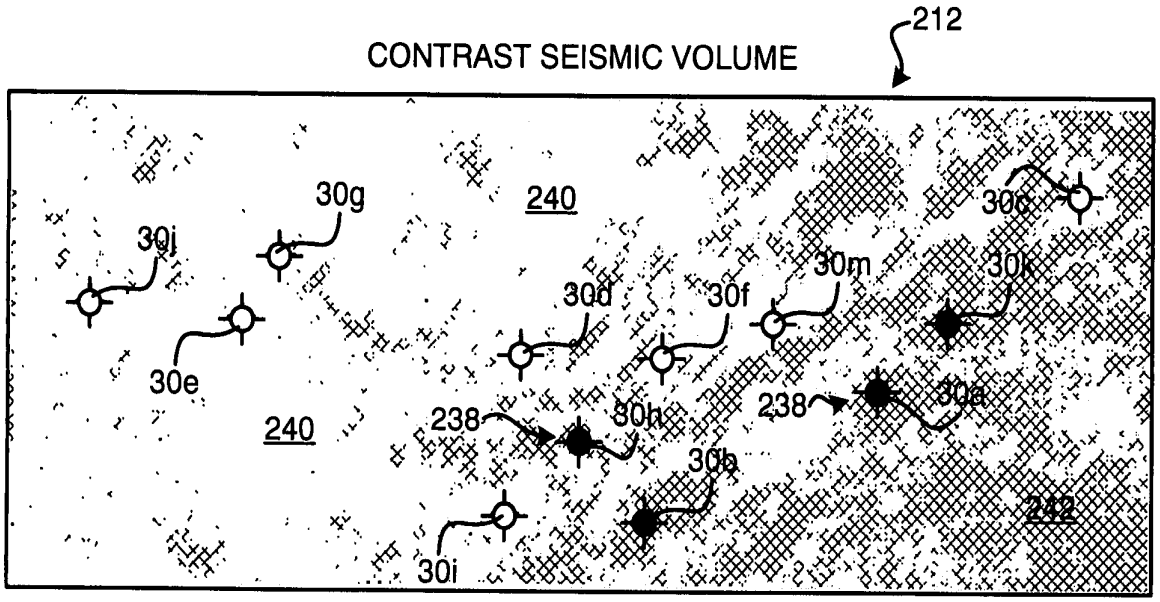


FIG. 37

CONTRAST SEISMIC VOLUME



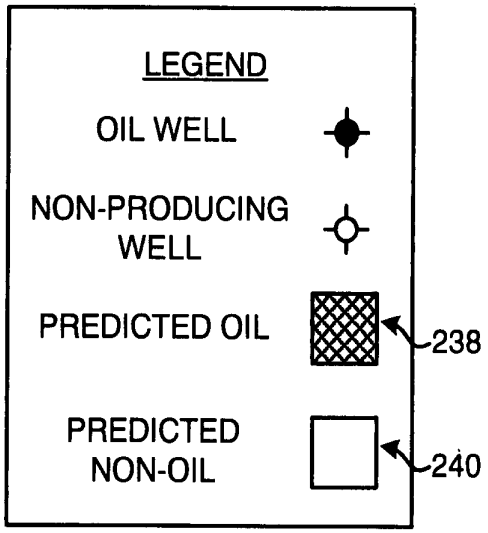


FIG. 38

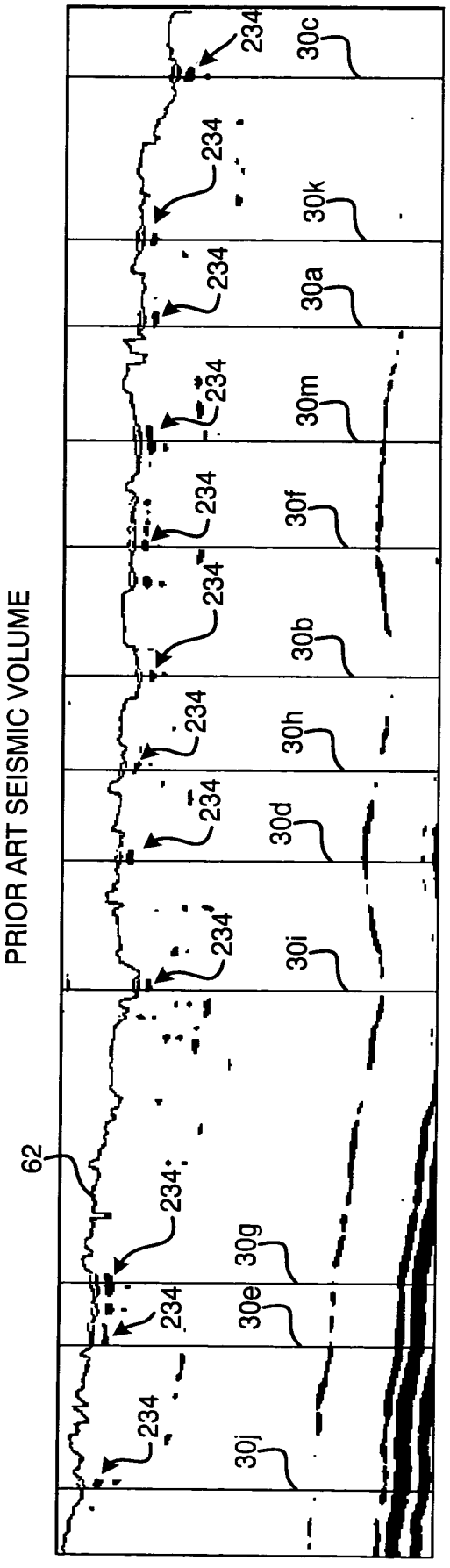

PRIOR ART SEISMIC VOLUME
62
234
30j
30e
30g
30i
30d
30h
30b
30f
30m
30a
30k
30c

FIG. 39

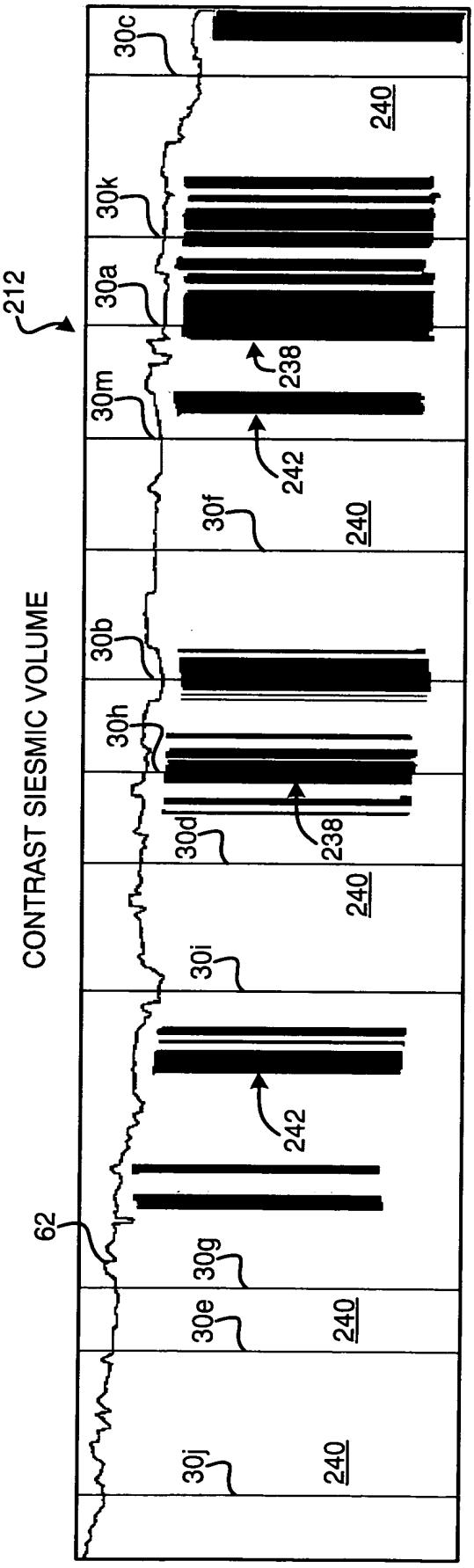

CONTRAST SIESMIC VOLUME
212
62
242
238
240
30j
30e
30g
30i
30d
30h
30b
30f
30m
30a
30k
30c

FIG. 40

236

	WELL	STATE	TIME	TRACES	USE
30a	1	OIL	0.976 - 1.176	169	CLASSIFY
30b	2	OIL	0.964 - 1.164	167	LEARN
30c	3	DRY	0.990 - 1.190	158	LEARN
30d	4	DRY	0.944 - 1.144	177	CLASSIFY
30e	5	WET	0.926 - 1.126	154	LEARN
30f	6	WET	0.960 - 1.160	171	CLASSIFY
30g	7	UNKNOWN	0.924 - 1.124	159	CLASSIFY
30h	8	UNKNOWN	0.950 - 1.150	163	CLASSIFY
30i	9	UNKNOWN	0.958 - 1.158	165	CLASSIFY
30j	10	UNKNOWN	0.920 - 1.120	163	CLASSIFY
30k	11	UNKNOWN	0.972 - 1.172	155	CLASSIFY
30m	12	UNKNOWN	0.966 - 1.166	170	CLASSIFY

FIG. 41

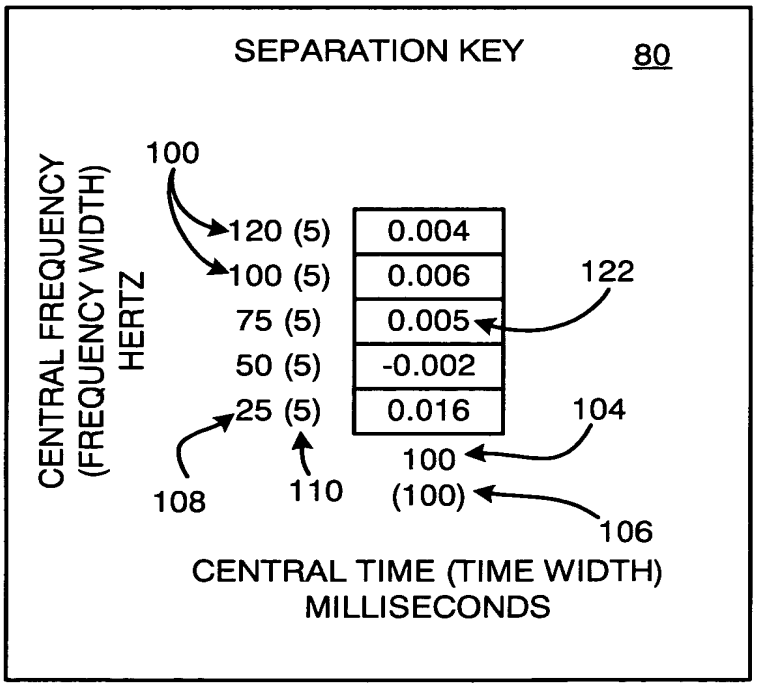


FIG. 42

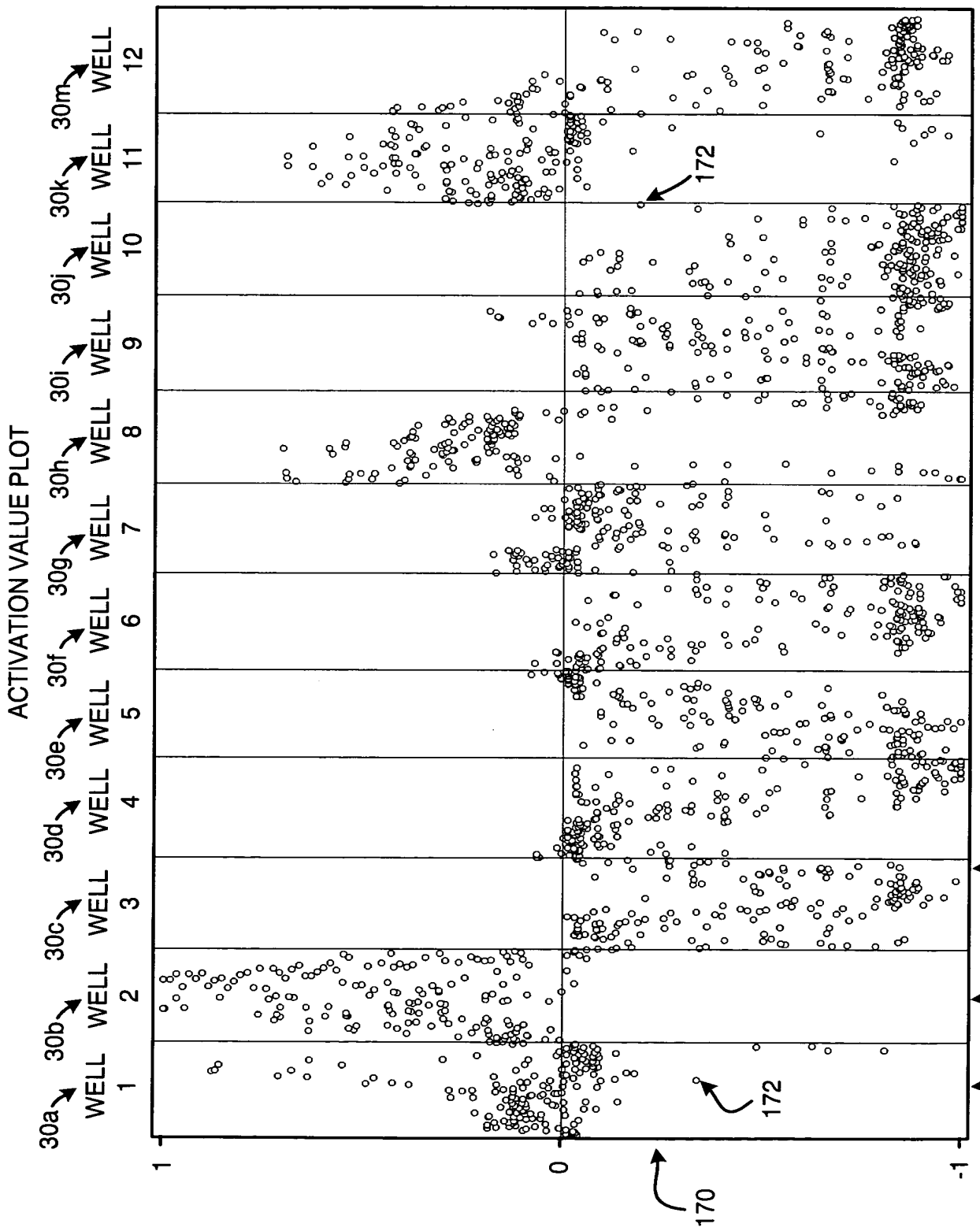
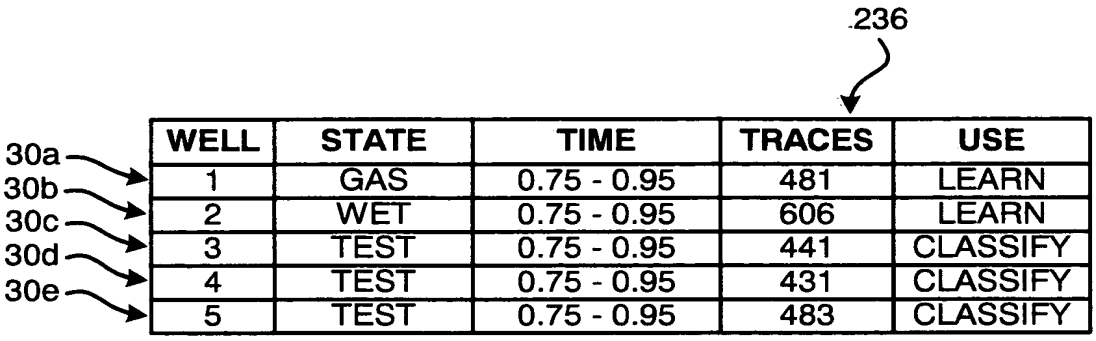

ACTIVATION VALUE PLOT
30a
WELL 1
30b
WELL 2
30c
WELL 3
30d
WELL 4
30e
WELL 5
30f
WELL 6
30g
WELL 7
30h
WELL 8
30i
WELL 9
30j
WELL 10
30k
WELL 11
30m
WELL 12
1
0
-1
170
172
172
168
174b
174a

FIG. 43



WELL	STATE	TIME	TRACES	USE
1	GAS	0.75 - 0.95	481	LEARN
2	WET	0.75 - 0.95	606	LEARN
3	TEST	0.75 - 0.95	441	CLASSIFY
4	TEST	0.75 - 0.95	431	CLASSIFY
5	TEST	0.75 - 0.95	483	CLASSIFY

FIG. 44

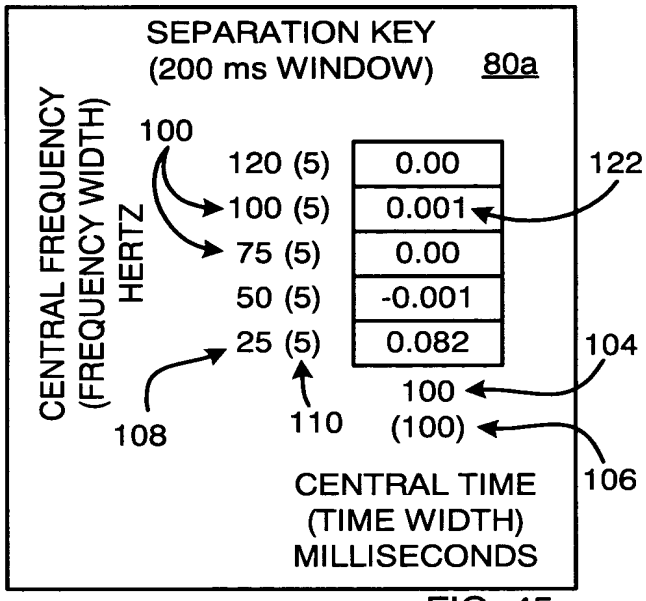


FIG. 45

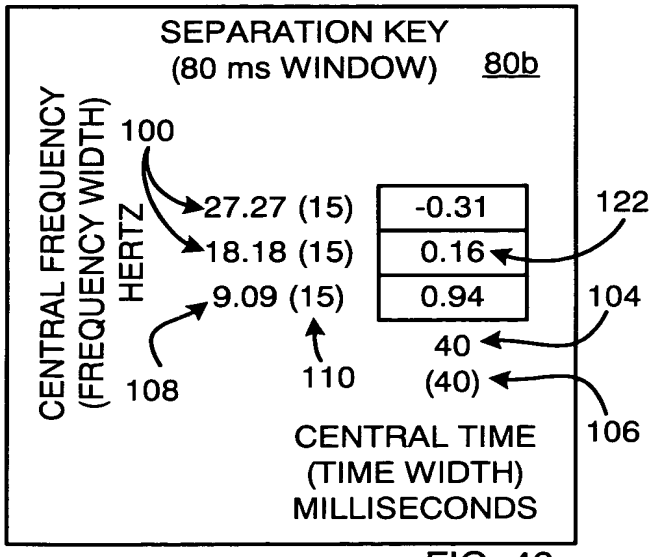


FIG. 46

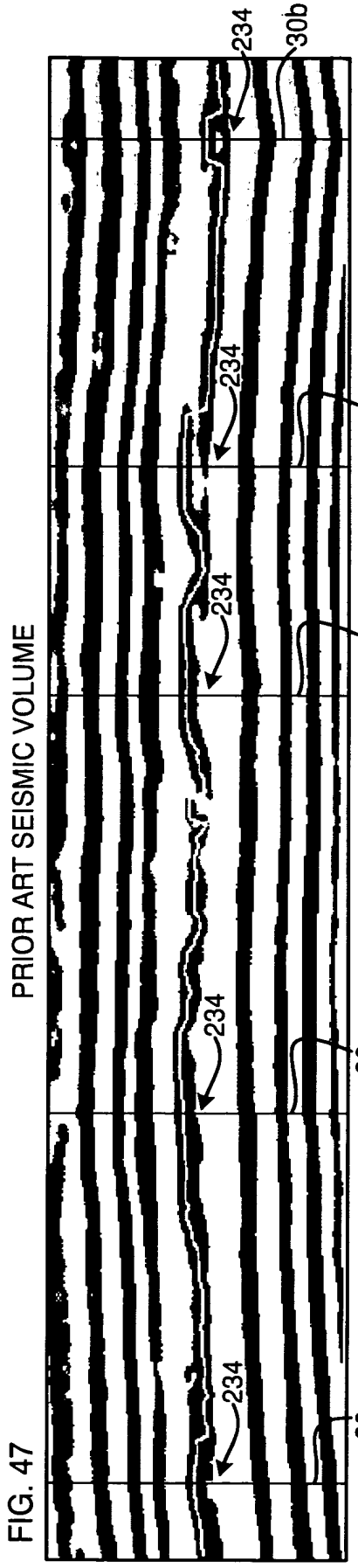


FIG. 47

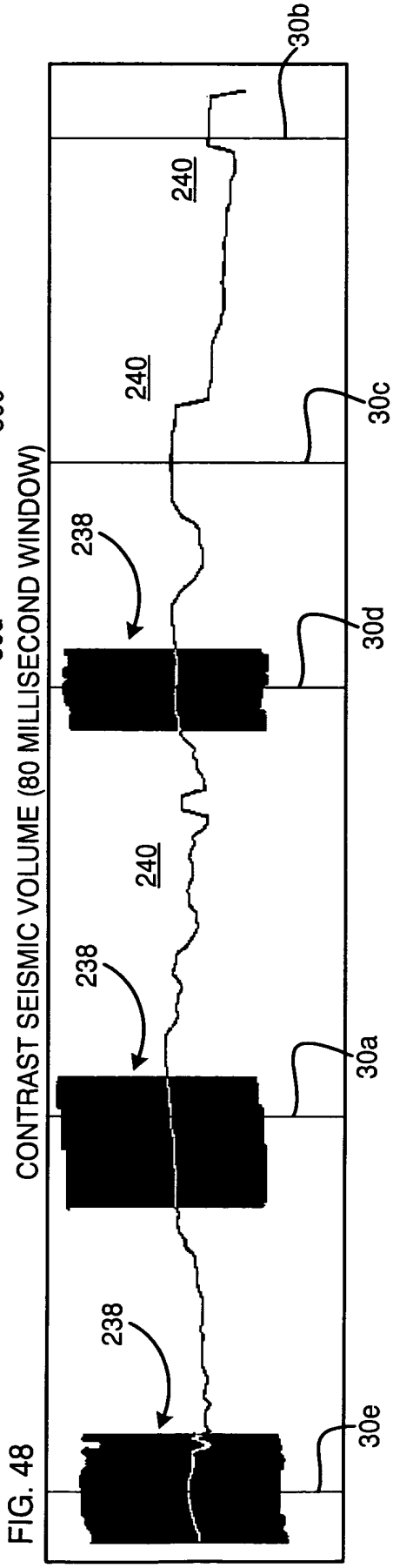


FIG. 48

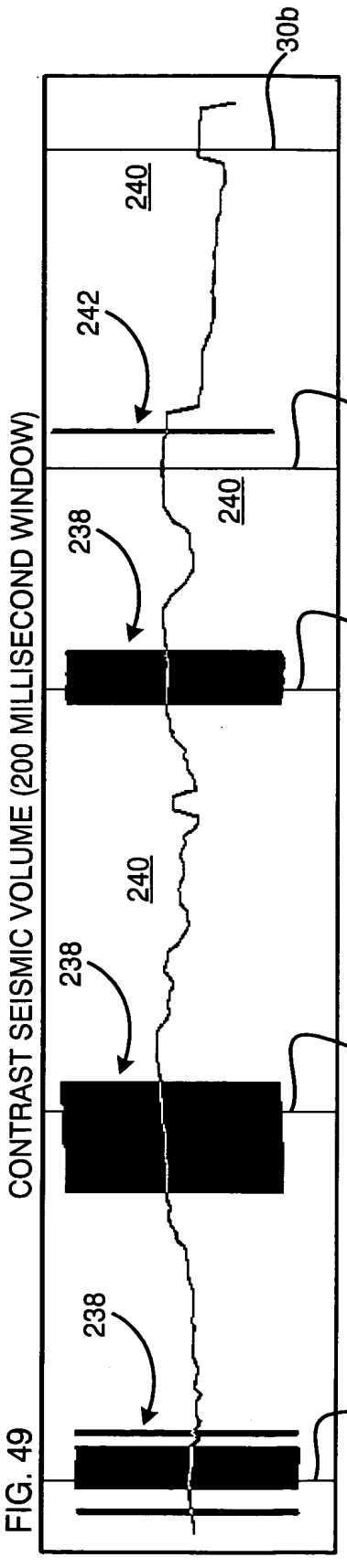


FIG. 49

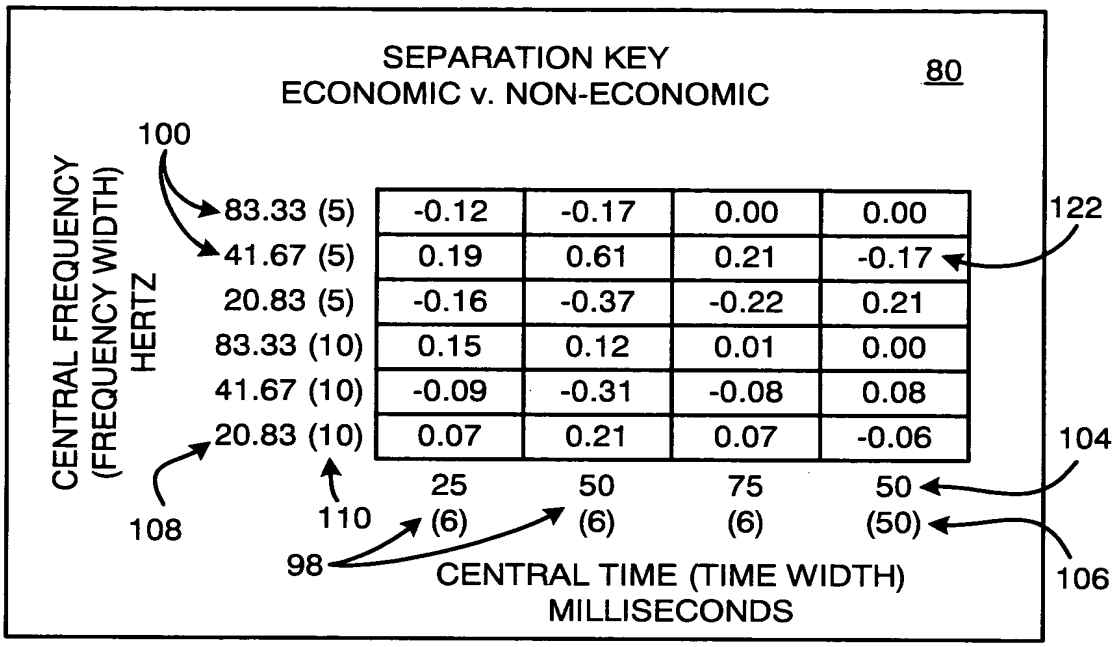

SEPARATION KEY
ECONOMIC v. NON-ECONOMIC
80
100
CENTRAL FREQUENCY (FREQUENCY WIDTH) HERTZ
83.33 (5)
41.67 (5)
20.83 (5)
83.33 (10)
41.67 (10)
20.83 (10)
-0.12 -0.17 0.00 0.00
0.19 0.61 0.21 -0.17
-0.16 -0.37 -0.22 0.21
0.15 0.12 0.01 0.00
-0.09 -0.31 -0.08 0.08
0.07 0.21 0.07 -0.06
122
104
25 50 75 50
(6) (6) (6) (50)
106
108
110
98
CENTRAL TIME (TIME WIDTH) MILLISECONDS

FIG. 50

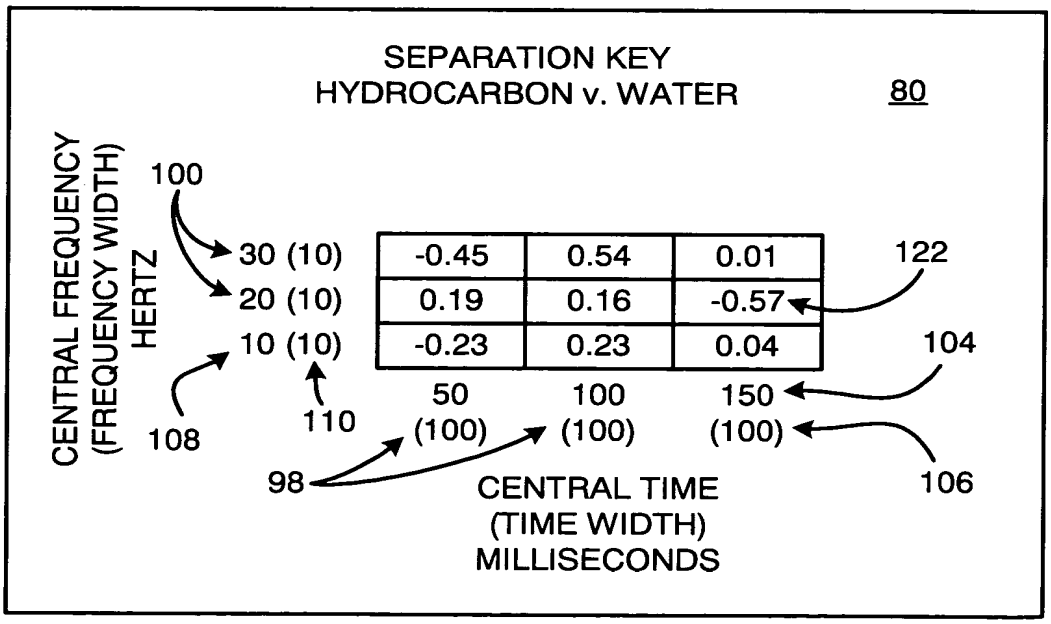

SEPARATION KEY
HYDROCARBON v. WATER
80
100
CENTRAL FREQUENCY (FREQUENCY WIDTH) HERTZ
30 (10)
20 (10)
10 (10)
-0.45 0.54 0.01
0.19 0.16 -0.57
-0.23 0.23 0.04
122
104
50 100 150
(100) (100) (100)
106
108
110
98
CENTRAL TIME (TIME WIDTH) MILLISECONDS

FIG. 51